Popular Science Talks

SEASON OF 1927-1928

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FOREWORD

The lectures which constitute this, the Sixth Annual Volume of Popular Science Talks, represent the effort of the Philadelphia College of Pharmacy and Science to contribute to the educational welfare of the community at large by means of popular scientific discussions.

These lectures are given annually by members of the Faculty of the College and cover a broad and interesting field of scientific subjects. They are not arranged in a course covering any particular field of science, nor is there any interdependence or connection between them. They are presented in a non-technical, easily understandable form, but without the sacrifice of scientific accuracy or completeness. Usually they are illustrated by appropriate experiments, specimens or lantern slides.

Following the second year of the presentation of these Popular Science Lectures by the College a demand arose for the lectures in book form, in spite of the fact that most of the lectures had appeared in the AMERICAN JOURNAL OF PHARMACY following their presentation.

This demand has been supplied for the past five years and the following volumes with their lecture subjects are available at a cost of $1 per individual volume, through the AMERICAN JOURNAL OF PHARMACY, Forty-third and Kingsessing Avenue, Philadelphia.

Volume I includes twelve lectures as follows: "Chemistry as an Aid in the Detection of Crime," "Corn and Its Products," "The Story of Glass," "Bacterial Preparations," "Another Drop of Blood," "The Romance of Spices," "Catalysis and Catalysts," "The Aluminum Age," "Animal Eating Plants," "Explosives and Explosions," "The Making of Medicines," "Iron and Iron Alloys."

Volume II includes eleven lectures as follows: "Invisible Light," "The Story of Rubber," "Chemistry in and About the Home," "Idiosyncrasies, or the Story of a Sneeze," "What is Chocolate?" "Sugar as a Medicine, Food and Poison," "Social Insects," "The Romance of Drugs," "Something About Gases," "Household Insect Pests," "Drugs of the North American Indians."

Volume III includes thirteen lectures as follows: "Arctic and Tropical Pennsylvania," "The Romance of Chemistry," "Chemistry and Color," "The Mineral and Vegetable Resources of the Sea,"

"Chemistry in and About the Home," "The Ups and Downs of Nitrogen," "Animal Aviators," "Practical Disinfection," "Why Soap?" "What Shall I Eat?" "Bridge Construction," "Chalk and Its Chemical Relatives," "Control of Growth in Plants and Animals."

Volume IV includes twelve lectures as follows: "The Romance of Medicine," "More About Color and Colors," "Coal and Coal Mining," "Environment—The Big Factor in Health and Disease," "Imitation of Life," "The Sign of the Skull and Cross Bones," "Delectable Confections," "The Flight of a Ball Through the Air," "The Diamond and Its Colored Brethren," "What Shall I Drink?" "The Salt of the Earth," "Abnormal Plant Growths."

Volume V includes eleven lectures as follows: "Paper," "The Romance of the Occult," "Epochs and Epoch Makers of Medicine," "The Story of Burnt Clay," "Hormones, Vital Substances in Life," "Epidemics, Man's Most Deadly Enemy," "My Lady Nicotine," "Sand From Mountain to Seashore," "What Shall I Wear?" "Why the Weather?" "Mosses and Their Message."

The new series arranged for this year (1929), a list of which appears at the end of this volume, will be found to include an entirely different array of subjects from that of any previous season.

THE ROMANCE OF COOKERY

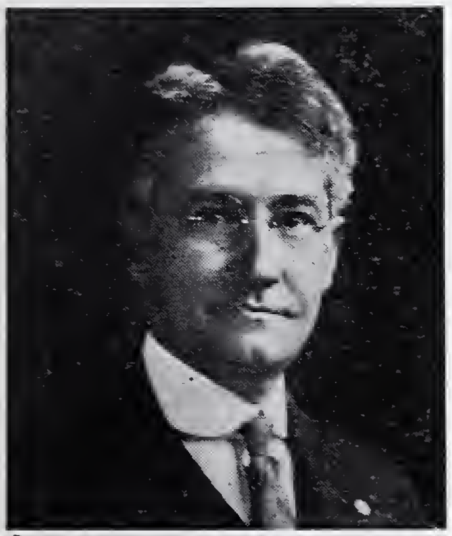
By Charles H. LaWall, Dean of Pharmacy

"We may live without poetry, music and art;
We may live without conscience, and live without heart;
We may live without friends; we may live without books;
But civilized man cannot live without cooks.

He may live without books—what is knowledge but grieving?
He may live without hope—what is hope but deceiving?
He may live without love—what is passion but pining?
But civilized man cannot live without dining."

—*Owen Meredith.*

LET US SUMMON to our aid upon this occasion the Greek host Amphitryon and the Roman goddess of good cheer, Adephagia, and let us spend an hour in the discussion of Aristology, the art of dining, and all that that implies.



Charles H. LaWall

All students of gastronomy prefer laboratory work to theory, but upon this occasion I shall act as a Barmecide host, and you must summon all your fortitude or I shall be compelled to make a hasty exit after having tantalized your gustatory emotions to the bursting point, for even as far back as Homer we hear of "the sacred rage of hunger."

Man as an animal has to eat to live, but as an omniverous epicure he frequently lives to eat. Our troglodytic forbears were the gastronomic pioneers of the world. We can conceive of them as being neither polite in their table manners nor finicky as to their fare. What we call today a "cannibal sandwich" may have been popular then, with less likelihood of its being misbranded. Even as late as the time of the Roman conquest of Great Britain the Scots were alleged to be *anthropophagi.* An *anthropophagus* resembles a philanthropist in that both love their fellow man; the former, however, loves him as the principal course at dinner. Perhaps that's why we hear so many stories about the closeness of the Scotch—their ancestry was so concentrated. It reminds us of the story of Queen Liliuokalani, who boasted that she had English blood in her veins, and not without some degree of truth, if you understand exactly how she meant it.

But how shall we start this feast of seasoning and flow of saliva? I know that you are anxious, for of Puritanic stock is the diner who does not sneak a surreptitious look at the menu as he unfolds his napkin, even though his neighbor may be discoursing in his ear about the fourth dimension or some such unrelated subject, and tonight, alas! we have no printed menus. Instead of *a la carte* you will have to be content with *table d'hote*. And what is more, you will take pot luck. This expression, still used today, is not interpreted as literally as its original significance.

In the old days the great family cooking pot was always kept suspended over the fire in the ample fireplace, from the familiar pot-hook. Anything and everything edible was thrown into this pot. When mealtime came, the family and guests fished for themselves, and what they might happen to get was "pot luck." I hope that each of you tonight may carry away a portion to his or her liking, and that none of you will suffer from mental indigestion afterward.

THE BEGINNINGS OF COOKERY

Nobody, I believe, will challenge the statement that "man is the only cooking animal," although Carlyle made an unsuccessful attempt to contradict it in his *Sartor Resartus*. The *ars coquinaria,* as the Romans called the art of cooking, has been traced by archæologists to our European ancestors of some tens of thousands of years ago, for by a detailed study of the debris of the kitchen middens of neolithic ages we can reconstruct, in part, the dietary habits of *Homo Neanderthalensis* and compare them with *Homo sapiens* or *Homo stultus* of the present. We know that from the earliest time man was omniverous and that both shellfish and game were important items of his fare.

When and how he learned to utilize heat in making his food more palatable and more digestible is a secret of the past. Charles Lamb's explanation in his classic "Dissertation on Roast Pig" is as good as any other, so let us agree upon that as a starting point.

In the Golden and Silver Ages the ancient poets painted the fabled past as a period of vegetarianism. It remained for the Bronze Age to inaugurate a flesh diet, according to these same authorities. It is not quite settled among Biblical students as to whether or not the antediluvians were vegetarians. Those who hold the affirmative of this view quote the admonition of the Lord to Noah, "Every moving thing that liveth shall be meat for you, even as the green herb have I given you all things." Well, Moses made a few revisions in the

dietary pharmacopœia of the Hebrews some time thereafter and laid down arbitrary and emphatic regulations regarding foods that are followed by the orthodox Jews even unto this day.

One of the most noted of cooked dishes in biblical history is the pottage of red lentils which had been prepared for Jacob, and which was so fiercely coveted by the hungry Esau, weary and faint from hunting, that he sold his birthright for a helping of it and changed the history of the Jewish race. It is said that Rabbi El Bassam, a celebrated Jewish theologian and commentator on the Talmud, spent fifteen years in vainly trying to discover the name of the cook who had prepared this wonderful dish. Perhaps he did it so that the descendants of Esau could enter suit against the sons of Jacob for damages with accrued interest.

"Meat" (in Ecclesiological Symbolism)
From an Old MS.

The most noted vegetarian of biblical history was Nebuchadnezzar, the mighty King of Babylon, who subsisted on a diet of grass for seven long years. From him have probably descended the large number who dislike spinach at the present.

SPARTAN DIET

It is probable that primitive man ate but once a day. Even in the earlier days of classic Greece this custom prevailed and it is said that Plato reproached the Sicilians with being gluttons because they had two meals a day. In Spartan days meat was eaten only infrequently, and the principal diet was a mysterious concoction called "black broth." Apropos of the reputed palatability of this pabulum, a Sybarite, after tasting it said, "I am not astonished that you Spartans are so fearless of death on the battlefield, since anyone in his senses would rather die than be compelled to live on such execrable food." This coarse and unlovely food of the Spartans must have given them qualities of endurance, for it is a matter

of historic record that the Sybarites were conquered and enslaved several centuries before the Spartans came under the Roman domination.

Cadmus the Phoenician, who is reputed to have originated the Greek alphabet, is said to have been the cook to the King of Sidon. This is not to be considered as conclusive proof that he invented alphabet noodles, however.

It is probable that the Greeks learned much concerning cookery from the Orientals and passed it on to the Romans. Wherever the Greeks obtained their alimentary inspiration, there must have been an almost inexhaustible source of supply, for Athenæus of Naucratis, a Greek grammarian and litterateur of the third century A. D. has left as his sole legacy to fame a work called the *Deipnosophistæ,* which is concerned almost entirely with banquets, dining, and amusements connected therewith, for the modern cabaret is not new but is a "throw-back" to the most ancient periods of which any record exists.

Athenæus' monumental work is in fifteen volumes and he quotes from eight hundred authors and twenty-five hundred separate works. Again we lament the bibliothecal bonfires kindled by Mohammedan and Christian bibliophobes of Alexandrian and later periods. Athenæus was a contemporary of Heliogabalus, one of the most luxurious living and dissolute of the Roman emperors, who contributed some novelties in the banqueting line which we shall discuss later.

Aristophanes mentions a famous dish in his comedy "Ecclesiazione," which contains mussels, two kinds of fish, brains, sauces piquante, herbs, honey, larks, doves, pigeons, poultry, rabbit heads, hares and wine. This veritable "one piece dinner" is said to have a name which is the longest in any language.

Lucullus, Vitelius and Geta were all predecessors of Athenæus, as was also Cleopatra with her famous feast at which she is said to have sacrificed a valuable pearl to add to the cost of the dinner. It is said that Cleopatra had prepared a banquet for Anthony, the obvious costliness of which had excited his astonishment. When Anthony expressed his surprise Cleopatra is said to have taken a handsome and valuable pearl which she dissolved in vinegar before him, and drinking to the health of the Roman triumvir said, "My draught to Anthony shall far exceed it." This is a good story, and will probably go on rolling down the ages, in spite of the fact that vinegar would not dissolve a pearl so promptly, and the story is doubtless as mythical as the tale of Cleopatra's death by the bite of an asp.

Cleopatra has been described as a frail, fragile, febrile creature. As a clinging vine she certainly adorned the family tree of the Cæsars, for she was a widow of Julius Cæsar, and the mother of his son, Cæsarion, when she started to vamp Marc Anthony.

The best-paid cook in history is the one who officiated when Cleopatra played a return engagement with Anthony as host. We are not acquainted with the details of this dinner for two, but Cleopatra praised it so highly that Anthony presented the cook with a whole city, in gratitude for his services.

To go back to Athenæus for a few moments, we find some entertaining and illuminating quotations. He says of cooking:

> "All books of cookery, all helps of art,
> All critic learning, all commenting notes
> Are vain, if void of genius, thou wouldst cook."

He gives a vivid picture of the responsibility of the master cook in superintending the preparation of a dinner:

> "Leave, leave that ponderous ham,
> Keep up the fire, and lively play the flame
> Beneath those lobster patties; patient here,
> Fixt as a statue, skim, incessant, skim.
> Steep well this small glosiscus in its sauce,
> And boil that sea dog in a cullender;
> This eel requires more salt and marjoram;
> Roast well that piece of kid on either side
> Equal; that sweetbread boil not overmuch."

The "glosiscus" and the "sea dog" were varieties of sea food not common to modern tables, but we must agree that for the main part, this picture of more than fifteen hundred years ago is still intelligible to a gastronomist.

Athenæus also said:

> "I like to see the faces of my guests,
> To feed them as their age and station claim;
> My kitchen changes as my guests inspire
> The various spectacle."

I am willing to wager that Athenæus, who was obviously a gourmet in the most complimentary sense of the word, would suffer from nervous prostration if he were exposed for a short time to the monotony of the modern hotel or restaurant menu, and a few so-called banquets or dining club luncheons of our period would send

him to the insane asylum. With all their extravagances and excesses many of the Greeks and Romans of two thousand years ago had a sense of the proprieties of dining and of cookery that is often lacking at the present time.

Archistratus, another Greek culinary philosopher, wrote a poem on "Gastrology" which became the creed of the epicures for centuries. These are his opening lines:

"I write these precepts for immortal Greece,
That 'round a table delicately spread,
Or three or four, may sit in choice repast,
Or five at most. Who otherwise shall dine
Are like a troop marauding for their prey."

Dionysius the tyrant of Syracuse, who was also a gastronomist, described the perfect cook nearly twenty-five hundred years ago in these illuminating lines:

"To roast some beef, to carve a joint with neatness,
To boil up sauces, and to blow the fire,
Is anybody's task; he who does this
Is but a seasoner and a broth maker.
A cook is quite another thing. His mind
Must comprehend all facts and circumstances;
Where is the place, and what the time of supper;
Who are the guests, and who the entertainer;
What fish he ought to buy, and where to buy it."

Artemidorus, a Greek writer of the second century, published a kitchen glossary of his time, and Timachidas, another Greek, was both a cook and a poet of high renown, and composed an epopee on the culinary art, which was inspired by the soul-compelling emanations from his spits and kettles.

Before we leave the Greeks we must not forget to mention the champion gastrolator of the ancient Hellenes. Milo of Crotona, who was six times victor in wrestling at the Olympic games, carried a four-year-old heifer on his shoulders around the stadium, and then ate the whole carcass in a single day. We must not forget that the Greeks had as their models in matters alimentary the Homeric heroes, who were neither fastidious nor dainty in their table customs. These classic exemplars prepared their repasts with their own hands. Ulysses surpassed the rest in the art of kindling a fire and laying a cloth. Patroclus drew the wine and Achilles had the responsibility of turning the spit.

THE SEVEN SAGES OF GREEK COOKERY Frederick Hackwood, in a work called "Good Cheer," says "To Greece belonged the honour of producing the original seven sages of the kitchen: Orion, who invented the white sauce, and Lampridas, the discoverer of brown sauce; Nereus of Corinth, who made the conger eel a dish fit for the gods, and Agres of Rhodes, who first taught the bone method of dressing fish; Atlantus, who made the most perfect restorative, and Euthymus, who cooked vegetables so exquisitely that he was named Lentillus."

Neither should we forget the potent potion of Circe, which, while not equal to that of Nepenthe, was worth having on hand in the family medicine chest for use in emergency. This was composed of "red wine, and in it barley meal and cheese and honey, and mighty drugs withall, of which, if a man drank he forgot all that he loved."

Lucullus Ponticus, the Roman Xerxes of the first century A. D., set a new record for extravagance when he spent the equivalent of $5000 of our present money (which must have been equal in purchasing power to many times that sum today) for a cozy little dinner for three. But when we learn that his guests were Cæsar and Pompey, we come to the conclusion that perhaps it was worth it. The Lasky's would pay more than that today just for the privilege of filming that scene.

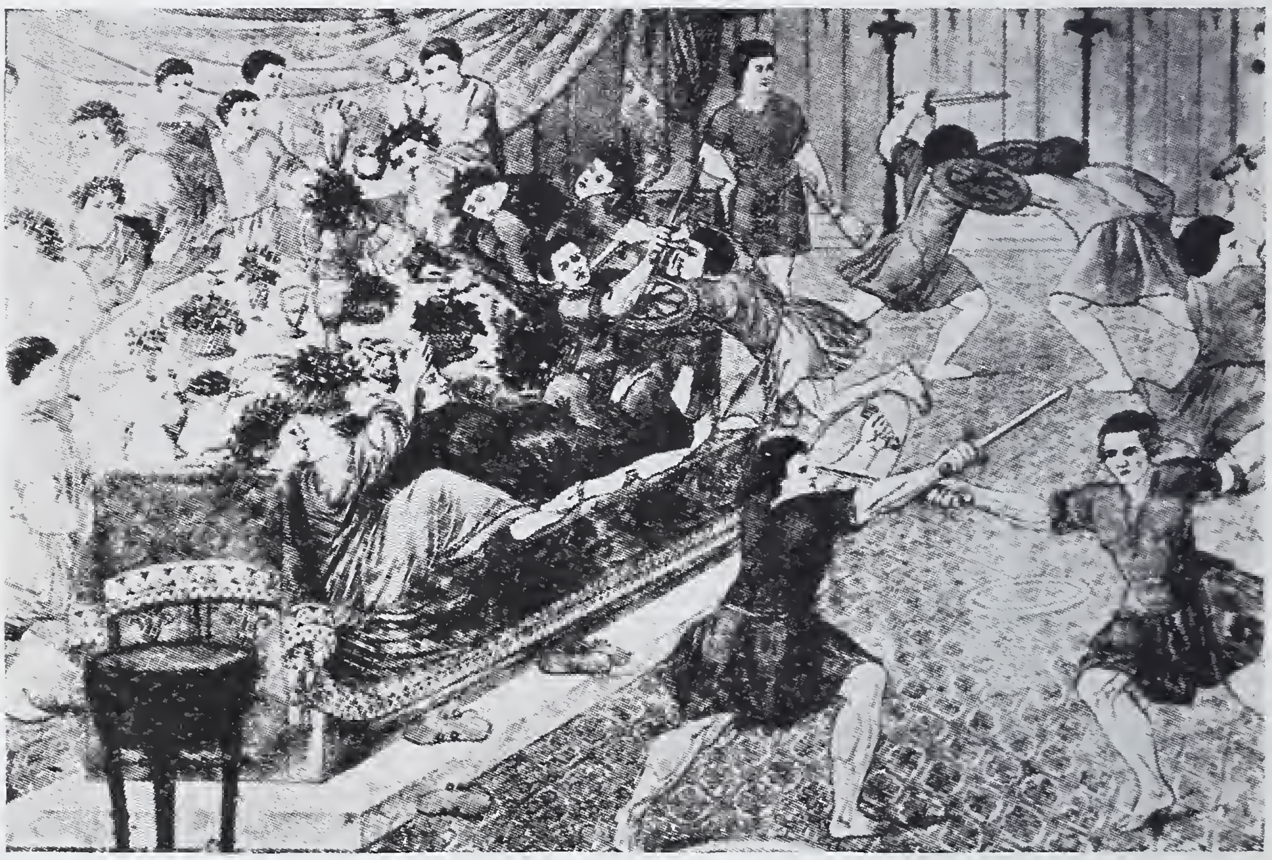
There were three celebrated Roman epicures by the name of Apicius. One of these, who lived during the time of Tiberius, is said to have spent nearly $4,000,000 in inventing rare dishes. Upon learning that he had only $360,000 left of his fortune, he committed suicide rather than continue existence upon such a miserable pittance.

Macrobius was a later Roman writer whose theme was conviviality and the pleasures of the table. Petronius was an earlier Roman satirist who was Nero's *arbiter elegantiarum*. He led a life of vicious indulgence which gave him the necessary background and information for descriptions of feasts which are unsurpassed by any early author. He fell from grace in Nero's favor and committed suicide at that Emperor's behest.

ROMAN FEASTS There were more gastronomic monomaniacs among the Romans than in any nation before or after. The Emperor Claudius was not content with fewer than six hundred guests at his table. Galba arose early in order not to miss breakfast, and the cost of this meal as served by him was considered extrava-

gant, even in that period of heroic feeders. Julius Cæsar spent the income of several provinces on a single meal. Besides being an accomplished general, Cæsar was not without interest in the diversions of life and was familiar with the tripartite realm of wine, women and song.

Geta insisted in having as many courses in the repast as there were letters in the alphabet, and all of the viands of each course were selected so as to have names beginning with the initial letter of that course, which would put a modern chef to some considerable trouble, even with the greater variety of foods from which to choose today.



A Roman Banquet With Gladiatorial Combat

Nero was accustomed to sit at the table from noon until midnight amidst the most monstrous profusion of viands and drink.

Vitellius, the friend and favorite of Nero, often spent more than the equivalent of $15,000 on a single meal, and he usually ate four meals a day. He was an exemplar of Roman omniveristic supremacy, for he is said to have consumed a thousand oysters at a sitting by introducing the abominable expedient of tickling the fauces with a peacock feather in order to make room for more. Even the great Julius Cæsar is said by Cato to have had some unpleasant habits, among which was that when he was invited to an unusual feast he would take an emetic to prepare himself to do proper justice to it. Ac-

cording to Gibbon, Vitellius spent the equivalent of six million pounds sterling on his table during the short space of seven months.

Tiberius had a most unpleasant table custom of starting an argument by asking his guests all sorts of strange questions, a sort of dinner table "Ask me another," and, in the discussion that followed, if Tiberius was worsted, his opponent was invariably asked to retire and commit suicide. This was not quite as bad as Caligula, who was in the habit of entertaining his dinner guests with private executions and the torturing of condemned criminals. One of his most grisly jokes was perpetrated on an occasion when the torturers had failed to amuse him. He rushed to the sacrificial altar attired only in a linen apron and seizing the mallet and swinging it as though he were about to slay the appointed victim, he swerved suddenly and butchered the chief executioner instead. He used to keep his dinner guests in good spirits by reminding them that he had the power to make victims of them instead of spectators.

Caligula fed his horse on gilded oats and compelled the senators of Rome to wait upon his dinner guests when the spirit moved him to that amusing diversion. Can you imagine Senators Borah and Reed waiting on President Coolidge's table?

Heliogabalus was a dinner jester of infinite variety. He loved to invite to a special dinner a number of very fat guests and then crowd them so close together that they could only perspire and not enjoy the repast. Another diversion consisted in having a large inflated couch on which his guests were invited to sit, and then in the midst of the dinner he would suddenly unexpectedly deflate this couch and tumble his reclining guests, dishes and all under the table. Mack Sennett, please take notice.

This emperor-comedian offered liberal premiums to the inventors of new sauces, but—if Heliogabalus disliked the sauce submitted, the inventor was condemned to eat of nothing else until he had discovered a condiment more pleasing to the imperial palate. On one occasion Heliogabalus had the heads of six hundred ostriches served at a banquet in order that the brains might be eaten. He also served camels' flesh at his banquets and considered camels' feet a great delicacy. It is doubtful whether Kipling ever thought of his "Gawd forsaken oont" as an addition to the diet of Tommy Atkins.

The Constantines had a thousand cooks. "They were accustomed to dine upon fowl from the most distant lands, fish from the most remote seas, to have for desserts fruits out of their natural

seasons, and to drink foreign wines cooled in the summer snows of lofty mountains."

Maximin, one of the most despicable of the Roman emperors of the third century, made a new world's record for individual capacity as regards food. He was a giant in size, being over eight feet tall and therefore entitled to extra-sized portions. Gibbon says that Maximin drank an amphora of wine every day (about seven gallons), and consumed from twenty to forty pounds of meat a day, in addition to other comestibles.

The Roman *coena,* or supper, was the principal meal of the day. The Roman dining-room was the *coenaculum,* was always in the upper part of the house, reached by an ample staircase. The tables were small and were changed with each course. The host and the guests reclined on couches, usually three in number (*triclina*).

The various services in connection with even the smallest dinner were performed by a number of domestic slaves. The *coquus* or cook was in complete charge of the dinner as regards its selection and its preparation. The steward at the head of the army of slaves was the *dispensator.* The purveyor was called the *obsonator.* The *vocatores* carried the invitations, and received and arranged the guests. The *cubicularii* arranged and decorated the couches and the *triclinarii* directed the repast, the dishes being carried to the table by the *depiferi* and announced to the guests by the *nomenclatores.* An attendant called the *structor* arranged the dishes on the table, after which the meats were cut up by the *scissor* or carver, who followed the rhythm of music played by unseen performers. Finally, the *procillatores* served the guests and acted as cup bearers. In some houses there was a *prægustator,* who tasted every viand before the guests were permitted to be served.

The Romans took five meals a day and ate voraciously at every one of them. Their formal feasts commenced with light food, such as eggs, and concluded with a dessert of fruit; from this custom arose the phrase *"ab ovo usque ad mala,"* "from the egg to the apples," that is, "from the beginning to the end."

WHY ROME FELL

The Romans also had a proverb *"Crapula quam gladius,"* which being liberally translated, means "While gladiators have slain their thousands, eating hath slain its tens of thousands." Many reasons have been given to account for the decline and fall of Rome. Too much luxury, too much indolence.

and too much bathing, have all had their proponents. The latest and most startling reason, given by E. Lucas White, in *Why Rome Fell,* is, too much Christianity. After this very brief outline of Roman cooking which I have given you, which covers many centuries, I suggest as another reason "too much good eats." It is a matter of record that the legionaries of Cæsar's time, each of whom carried his whole month's rations in addition to other impedimenta, the whole totalling more than sixty pounds per man, were the best fighters that Rome ever had. From the time of Domitian on they were fed better and fought worse than ever.

The Marriage Feast at Cana of Galilee

Cooking is different from dietetics or nutrition. It is an art which is essential to human happiness and contentment, but whose perfection is associated with luxury, voluptuousness, and decadence. Just as ancient Rome exemplifies this latter statement, so does the period of the frivolous French monarchs who harassed their prime ministers in order to provide funds for feasts emulating those of the Romans, whose tables had become traditions of luxuriance and extravagance. The renaissance, which was accompanied by much plain living and high thinking, was followed by the post-renaissance period of profligacy and profusion.

Catherine de Medici was probably the connecting link between these two periods. Montaigne credits her with having stimulated the revival of the art of cookery in France by importing Italian cooks into Paris. She must have inaugurated a wave of interest in cookery, for shortly after her death Sir Thomas Burton, the distinguished author of "Anatomy of Melancholy," said: "Cooking is become an art, a noble science; cooks are gentlemen." There must have been a flareback in England also shortly after this time, for John Taylor said in 1630: "God sends meat and the Devil sends cooks."

FINGERS AND FORKS

The Italians had undoubtedly done for cookery during the Dark Ages what the Arabs had done for letters and for science, for the first gleam of hope came from that land in the sixteenth century when the cook of Pope Leo X invented fricandeaus and in the following century the Italians originated ices and brought the idea to France, where they became very popular. Leo X himself must have been something of an experimenter in alimentary accessories, for it is said of him that he made more sauces than saints. The Italians had also commenced the use of forks a century previous to their use in France and Great Britain. It was an English traveler named Thomas Coryate who first made them known to his countrymen and stated that the custom of using a fork instead of the fingers was very general in the early part of the seventeenth century in Italy, but had not been observed by him in France, Germany, Switzerland, or in his native land. It was James I who attempted to introduce the practice of fork-using into England and who was contemptuously nicknamed *Furcifer* for so doing.

We can scarcely visualize the dinner table scene of the time of Good Queen Bess, as described by a contemporary poet:

> "If the dish be pleasant, either fleshe or fishe,
> Ten hands at once swarm in the dishe;
> And if it be fleshe ten knives shalt thou see,
> Manglin the fleshe, and in the platter flee,
> To put there they handes, in peril without fail
> Without a gauntlet or else a glove of mail."

And yet this period, crude as it may seem, was far in advance of the barbarous baronial times of a couple of centuries before.

LIVERIES AND SOTELTIES

As early as the fifteenth century the English commenced to serve four meals a day, *viz.*, breakfast, dinner, supper and livery. The latter was a light repast of bread and beer, of sweet cakes and wine or spiced liquor

served in the bedchamber before retiring. This was made possible by livery cupboards, holding small quantities of food, placed in the bedrooms. There was no need in those days for a midnight foray upon the refrigerator on the part of a hungry soul, even if there had been a refrigerator to raid.

The Elizabethan Era was the time when subtleties (spelled "sotelties") were about at the zenith of their popularity. These were devices, usually of sugar or of pastry, or sometimes of meat dishes, which not only served to adorn the table but taxed the ingenuity of the cook. At one of these ancient banquets the subtleties consisted of a pelican sitting on its nest, an image of St. Catherine, a panther, and numerous others. Even such ambitious scenes as the Fall of Troy and other episodes in history or mythology were attempted by these culinary artists.

The cooks of that time were as anxious to please the eye as to satisfy the palate. Their finest dishes were adorned with gold or silver foil or decorated with various colored powders. Among special subtleties or decorative dishes the peacock and the swan played a prominent part at this time. To quote verbatim from a description of one of these affairs:

> "The peacock was skinned, stuffed with spices and roasted. While the cooking was going on a cloth continually wetted was kept continually around the bird's head to save it from the fire. When cooked it was allowed to cool and then the skin was neatly sewn on again, the tail feathers spread out, the comb gilt, and a piece of cloth dipped in spirits of wine placed in its mouth, to be set on fire while it was being served up at table, which was accompanied by some ceremonial. The serving was performed by the ladies most distinguished for rank and beauty, following the dish in procession to the music of minstrels, who placed it in front of the guest most famed for courtesy, or, if it were after a tournament, the victorious knight, who took a chivalrous oath of valour or enterprise on its head."

The swan was served in a similar regal style.

Gentlefolk at this time breakfasted at seven off bread and beef, ale and wine. Dinner followed at ten and often lasted until one. Supper generally came at four and was as substantial as the breakfast, and between eight and nine the livery or evening collation, consisting of bread, ale, and spiced wine, was generally served in bed. The original meaning of breakfast is a *break* in the overnight *fast,* dinner literally means to "un-fast," while supper is derived from the root

word giving us sup, sip, soup, and sop. Lunch comes from a word meaning a lump or chunk, because it originally consisted of lumps of bread and meat.

Beaumont and Fletcher satirized the culinary extravagances of their time at some length. It remained for Ben Jonson to introduce to us the Elizabethan cook in a rhapsody which has never been equalled by any other writer:

"A master cook! Why, he is the man of men,
For a professor; he designs, he draws,
He paints, he carves, he builds, he fortifies,
Makes citadels of curious fowls and fish.
Some he dry-ditches, some motes round with broths,
Mounts marrow bones, cuts fifty angled custards,
Rears bulwark pies; and for his outerworks,
He raises ramparts of immortal crust,
And teacheth all the tactics at one dinner—
What ranks, what files, to put his dishes in,
The whole art military! Then he knows
The influence of the stars upon his meats,
And all their seasons, tempers, qualities;
And so to fit his relishes and sauces.
He has nature in a pot 'bove all the chemists
Or bare-breeched brethren of the rosy cross,
He is an architect, an engineer,
A soldier, a physician, a philosopher,
A general mathematician."

To carry our story across the English Channel for a change, we find that Louis XIV encouraged the beginning made by Catherine de Medici. Bechamel, whose name is still attached to a white sauce of elaborate composition, was *maitre de hotel* or chief steward of that monarch. Soubise sauce, which is made principally from onions, was devised by the Prince Soubise, who led the heroic but unsuccessful defense of Rochelle. The great Conde, also of this same period, had a cook named Vatel, whose name is immortalized among the members of the culinary fraternity from the fact that in his chagrin and grief at the tardy arrival of a fish, which was to serve as an important course at a meal which he was preparing, he committed suicide.

Louis XV was a gourmet of distinction during whose reign the culinary art saw many innovations. Many of the special entrees and dishes on menus printed in French owe their original nomenclature to this period. Sauce Richelieu is named for the duke (not the car-

dinal) of that name. According to some authorities he originated mayonnaise, originally called mahonnaise, because of his celebrated capture of Port Mahon. Another explanation is that this popular salad dressing originated in Bayonne and was originally called Bayonnaise, later corrupted to the present name.

THE "CORDON BLEU"

The phrase *"cordon bleu,"* literally blue cord or ribbon, which was applied as a term of distinction in connection with several military or holy orders, was applied to a cook for the first time during the reign of Louis XV. This epicurean monarch, having expressed his opinion very emphati-

A Kitchen of the Sixteenth Century. By Teniers

cally to the effect that only a man could cook to perfection, aroused the interest of Madame du Barry, who had a dinner specially prepared for the King by her woman cook (*cusinière*). The dinner was such an unqualified success that Louis XV demanded the name of the cook in order that so valuable an artist might be added to his staff. Upon revelation of the fact that a woman cook had prepared the meal, the King, at the demand of Madame du Barry, conferred upon the artist the Royal Order of the Holy Ghost, which carried with it the *cordon bleu,* hence this phrase is now commonly applied to a distinguished woman cook.

One of the noteworthy facts of the seventeenth and eighteenth centuries is that men of eminence in the medical profession were not above writing works on cookery. Among such may be mentioned Sir Theodore Turquet de Mayerne, the father of the First London

Pharmacopœia; Sir Kenelm Digby, the originator of "sympathetic powder," and John Hunter, the noted British surgeon. That cookery is not incompatible with medicine is confirmed by the fact that the Latin word *curare* not only means to cure, but also to dress a dinner.

COOKERY CAMOFLAGE

From the very earliest Greek and Roman times one of the objects of expert cookery was to so disguise a dish that it bore no resemblance to the constituents from which it had been prepared. Bechamel, upon one occasion, is said to have used his art with such consummate skill that he dressed

Meats. From an Old Print

a pair of His Majesty's old slippers in such an appetizing form for a banquet that all of the courtiers declared it the best dish they had ever tasted. This same culinary artist, on a certain Good Friday, served the King with a dinner apparently consisting of meat and fowl, but in reality it was a Lenten dish composed wholly of vegetables.

Another celebrated example of this kind is where the cook of one of the early Greek kings, having heard his master express his longing for a certain small fish, when the King and his retinue were on an expedition far from the waters where such fish were obtainable, succeeded in counterfeiting the fish by means of a turnip carved into the proper shape, salted, seasoned and disguised with poppy seeds, so

successfully that His Majesty pronounced it an excellent fish. Some modern restaurants still possess this talent, but not intentionally in all cases, as exemplified by the patron who called the waiter back and said, "If this is coffee bring me tea, but if this is tea, bring me coffee."

Restaurants had their origin and rise in France during the latter part of the eighteenth century. The records show that in 1770 there was but one establishment in Paris which was called by that name and which functioned only for meal service and not for lodging as well, as had always been done by inns, taverns and hotels, and that within the short space of twenty-five years the number had increased to more than five hundred. The word restaurant literally means a restorer. The Latin student's etymological analysis of the word is worth quoting here. He said it was derived from *res,* a thing, and *taurus,* a bull, because it was a "bully thing."

The French Revolution gave Parisian cookery a temporary setback, but in 1804 a work was published which was the first great effort at investing gastronomy with the dignity of an art. This was the celebrated *Almanach des Gourmands,* a monumental work on cooking and dining. The word "gourmand" at that time was synonymous with "gourmet" or "epicure," and meant a connoisseur in the delicacies of the table. At present "gourmand" is usually employed to designate a greedy feeder or a glutton, while the other terms mentioned retain their original significance.

Napoleon was surrounded by a number of culinary experts. Robert, after whom the Sauce Robert was named, was a celebrated chef of this period, and he, together with Rechaud and Mérillon, were called the Raphael, Michelangelo, and Rubens of cookery. Other distinguished authorities of about this same period were Ude, Francatelli, and Soyer.

Napoleon was not a gourmet, but it is said that when on a campaign his cook had orders to put a fresh chicken on the spit every twenty minutes, in order that the Emperior might not be kept waiting when he wished to dine. It was in Napoleon's time that Carême served as cook to many noted persons, including Talleyrand, Emperor Alexander I, Baron Rothschild, and George IV.

LAWYER AND KITCHENER TOO

Brillat-Savarin (1755-1826) is the greatest name of all in the history of cookery. His *magnum opus,* the *Physiology of Taste* (*Physiologie du Gout*) was published in 1825, just before his death. The subtitle of this inter-

esting work, which has recently been published in English with an introduction by Arthur Machen, is *Meditations on Transcendental Gastronomy.*

Brillat-Savarin was not a chef, as many mistakenly believe, but a modest French advocate or lawyer, who fled to America for safety's sake during the Reign of Terror, and who, while in this country, supported himself by giving lessons in French and playing the violin in a New York theatre. In 1796 he returned in safety to France and shortly thereafter became a local magistrate, which position he occupied until his death.

He was a member of that brilliant circle of which the nucleus was Madame Recamier, who was his friend and relative. Among the aphorisms of this brilliant and witty writer are the following:

> "Beasts feed; man eats: the man of intellect alone knows how to eat."
> "Tell me what you eat: I will tell you what you are."
> "Drunkards and victims of indigestion are those who know not how to eat or drink."
> "The most indispensable quality in a cook is punctuality: and no less is required of a guest."
> "The fate of nations hangs upon their choice of food."

He also says:

> "If we take a broad survey we shall discern three kinds of *cooking:* The first, which has to do with the preparation of food, has retained the original name;
> "The second is applied to the analysis of food and the ascertaining of its elements, and is usually called *Chemistry;*
> "And the third, which may be called restorative cooking, is better known under the name of *Pharmacy.*
> "If their ends are different, they are as one in their common use of fire, furnaces, and many of the same vessels."

Brillat-Savarin adds a tenth to the nine recognized muses. He names her *Gasterea,* and says that "the delights of taste are her domain." Speaking of concentrated sauces he relates the following interesting story of the Prince de Soubise, whose name has previously been mentioned in connection with the onion sauce which still bears his name. It was as follows:

> "The Prince de Soubise one day wished to hold a reception; it was to end with a supper and he sent for the bill of fare. His steward appeared at his bedside with a highly ornate card on which the first item to meet the princely eye was 'fifty hams.'

'Bertrand,' he exclaimed, 'what is the meaning of this piece of extravagance? Fifty hams! Do you want to regale the whole of my regiment?' 'No, *mon prince;* only one ham will appear on the table; but I shall still need all the rest for my dressings, my sauces, my——'

" 'Bertrand, you are a thief, and I shall not buy those hams.'

" 'Ah, but *mon seigneur,'* replied the artist, 'you do not know our resources! You have but to say the word and I will take every one of those offending hams and put them all together into a crystal vial no bigger than my thumb.'

"What was to be said to so hardy an assertion? The prince smiled, nodded assent, and the item was allowed to pass."

OSMAZOME, ETC.

Brillat-Savarin pays the highest compliment to the delicacy of the sense of taste when properly cultivated. He speaks of a Roman gourmet who was able to distinguish, merely by the difference in flavor, a fish caught between certain bridges from one caught further down the river. He also tells of some of his own contemporaries who could distinguish the particular savour of a leg on which the partridge rests its weight while sleeping. He uses a term unfamiliar to us in the word "osmazome," which he says is the essential flavoring constituent of meat, and which gives the characteristic flavor to properly-made bouillon.

He also describes in detail the coffee percolator of Dubelloy, which is a landmark in the early history of percolation, soon thereafter adapted to the needs of pharmacy, where it now finds its greatest usefulness. It was probably the influence of Brillat-Savarin that led Alexander Dumas, Sr., to write *The Grand Dictionary of Cookery,* a comprehensive treatise on the subject.

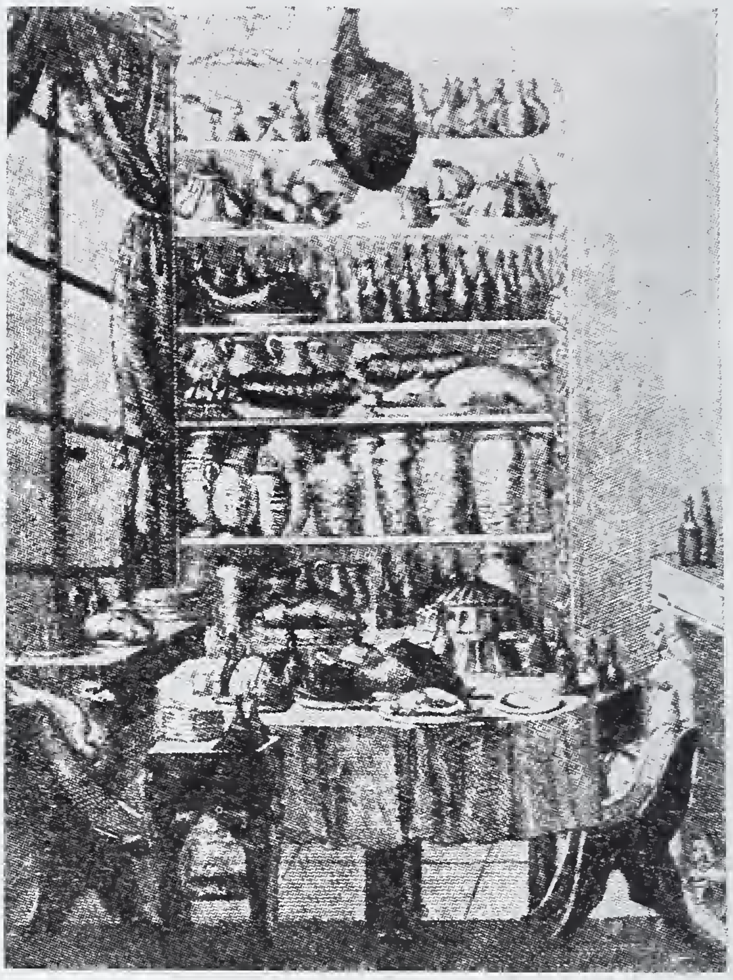
Cookery books, especially old ones, are delightful reading—except for dyspeptics. They are tantalizing sometimes, in their allurement, for they conjure up visions of new culinary possibilities and gustatorial experiences. In passing, we wonder whether a bookworm would find special enjoyment in eating its way through a library of this kind.

SYLLABUBS—FLUMMERIES—TANSIES AND FOOLS

The very nomenclature is quaint and intriguing. We read of desserts whose names have a lilting sound and are enigmatically attractive, whose very character and classification may often be inferred on onomatopœic grounds. "Almost singing themselves as they run" as the herbs in Kipling's "Fathers of Old." Syl-

labubs, flummeries, tansies, and fools—who would not like to top off a meal with one of these! And as for drinks—we yearn for a posset with a sippet floating in it, for a caudle, for hippocras, mead, and sack—the latter a potation whose exact identity has eluded both antiquarian and culinary research.

We crave a jugged hare or a platter of wigs. We hunger for a breakfast of frumenty and collops or a gammon of bacon or ham. We would not refuse a luncheon of cullis and salimongundy, or an olio or a frigacy or some collared or soused beef, topped off with a



The Gourmand's Library

panada or march pain or an apple fraze or an apple pupton with biskits on the side. We recognize what is meant by apricocks, oringes, plummes (or plombes), and damosens. Caboche eludes for a moment until we find it directed to be boiled with ham, and sallary soop is easily intelligible. We rather doubt the statement that cocks' combs make a pretty plate at supper.

The name Battalia pie temporarily attracts us, but we lose our ardor when we learn that it is composed of chickens, pigeons, rabbits, lambs' tongues, cocks' combs and oysters. This seems to be a combination of gastronomic incompatibilities. These were the days when a jellied dessert was made from hartshorn (the shavings of the horn

of the hart or deer), calves' feet being an alternative. Manufactured gelatin is less than a century old.

There seem to be no culinary tariff walls between nations when it comes to studying cook books either old or new. One must be a gastronomic cosmopolite or suffer from international indigestion. Nutritional necessities are crowded into a corner by omniverosity. There are neither radicals nor conservatives; there are only liberals. And "there were giants in those days," if we are to judge by the recipes published in Colonial times. They think nothing of directing a half peck of flour as the initial ingredient in a cake recipe, and as for eggs and butter, they seem to have used them with an entire disregard for either the pocketbook or the pylorus.

One of these older cook books where both the individual recipes and the meals assume heroic proportions when viewed in the light of our comparatively microscopic appetites, is by Mrs. Glasse. It is a "new edition," and was published in 1788. In the preface the candidate for the *cordon bleu* makes a bid for economy when she reproaches a contemporary with using six pounds of butter to fry twelve eggs, when, as she says, "Everybody knows, that understands cooking, that half a pound is enough." We shall not quote any of her recipes in detail. They are elevating as to character but depressing as to quantity. But just for an insight into the appetites of the English in the days of *Georgius Tertius,* let us scan a suggested menu of this authority. Let us take the month of January, for example. I shall not attempt to translate the names of unfamiliar dishes; I shall simply quote verbatim:

JANUARY (a Dinner)

First Course

	Chestnut Soup	
Leg of Lamb	Petit Patties	Boiled Chickens
Chicken and Veal Pie	Cod's Head	Roast Beef
Tongue	Raisolds	Scotch Collops

Second Course

Marinated Smelts	Vermicelli Soup	Woodcocks
Roast Sweetbreads	Tartlets	Mince Pies
Almond Tort	Stands of Jellies	Larks
Roast Turkey	Maids of Honour	Lobsters

Third Course

Artichoke Bottoms	Dutch Beef, Scraped	Macaroni
Custards	Cut Pastry	Black Caps
Scalloped Oysters	Potted Chars	Stewed Celery
Morels	Rabbit Fricaseed	

Need any comment be made? How could anyone here look the second course in the face, to say nothing of the third?

Mrs. Glasse was not the only one of her kind, for I have another old volume by Ann Peckham of Leeds, England, whose claim to favor as related in her preface is that the book is the result of forty years of experience with the best families in and about Leeds, and that "it is not stuffed with a nauseous hodge-podge of French kick-shaws." Let us see what Ann plans for a dinner in December. We find that Ann does not divide her dinner into courses, but instead she gives a bird's-eye view of the properly arranged dinner table for the month mentioned. Her bill of particulars names thirty-four counts in the indictment, as follows:

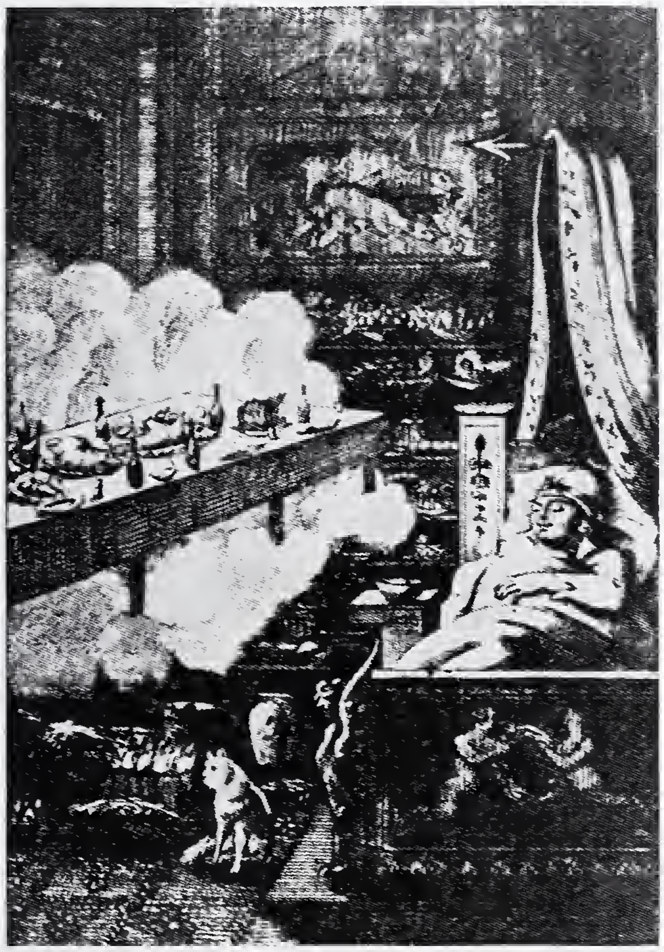
1 Soup, fish, pheasant
2 Broiled chickens
3 Oranges
4 Sweetbreads
5 Shenel
6 Oyster loaves
7 Ambassador cream
8 Jellies
9 Bacon and eggs
10 Woodcocks
11 Wine sours
12 Teal
13 Cheesecakes
14 Puddings
15 Limes
16 Cherries
17 Mutton chops
18 Dry sweetmeats
19 Veal olives
20 Damsins
21 Apricots
22 Tarts
23 Partridges
24 Rhenish cream
25 Ham
26 Stewed pigeons
27 Cards
28 Strawberries
29 A turkey
30 A trifle
31 A hare pie
32 Quince
33 Palates
34 Soup, fish, venison.

Are you going down for the third time? Have you had enough? Twelve kinds of meat, three kinds of fish and shellfish, besides the eggs, fruits, puddings, creams, etc. Before you lose consciousness entirely let me whisper in your ear that Ann Peckham has no mercy on her guests, for she gives a specimen December supper which contains thirty-five items, with such trifles as boiled turkey, woodcocks, partridges, wild ducks, snipes, and venison, with custards, syllabubs, and tansies galore.

How did they do it? How did any survive to tell the tale? And remember these are not intended for banquet menus, they are just for ordinary home folks, "even as you and I."

Perhaps you think that heavy eating was an English specialty, from the foregoing examples. Think not so. In a recipe book of

Queen Charlotte of Saxony, a robust ruler of the Middle Ages, to whom the kitchen was not a *terra incognita,* as it frequently is to a modern woman, even of moderate circumstances, there is a recipe for a stew which begins with the following startling sentence: "Kill a swine and hew it in pieces"—just like that. A recipe for food for an invalid was as follows: "Place a bucket of water on the boil. When hot, stir in gently forty eggs. Add sufficient honey, free from the comb, to sweeten, and two skins of Bordeaux wine." What stalwart invalids they must have been called upon to nurse back to health and happiness.



The Gourmand's Dream

An ordinary German dinner of that period consisted of fourteen courses with nine wines, while a special dinner called for seventeen courses and sixteen different forms of liquid joy in the shape of wines, punches, and liqueurs. In all times there have been those who believed that a dinner could be properly viewed only by occasionally looking at it through the bottom of a glass.

The Germans of that time had what were called *schau-essen,* literally "show eats," which were for exhibition purposes only and not to be consumed. These were carried around the table at the conclusion of a course, or series of courses, before beginning the next

one. On one occasion of record the guests are said to have sat down at midday to a dinner of sixteen heavy courses. At six o'clock they resumed eating, with a light repast of twenty-seven courses.

FUNERAL PIES Wakes, or funeral feasts, were great occasions for consuming food. The mourners at the obsequies of Prince August of Hanover in 1698 allayed their grief with twenty-one courses, each containing a choice of three dishes. In some sections of our own country funerals call forth the culinary resources of the bereaved family in looking after the physical needs of the mourners. In Lehigh and Berks Counties of Pennsylvania, raisin pies are called "funeral pies" because they may be baked several days before they are needed without becoming inedible. These preparations were necessary because of the sparsely settled country, and the long distances the relatives and friends were compelled to drive to the funeral.

In justice to the makers of these gigantic old-time meals, it may be that they were necessary, in many cases, by the large families, including relatives, guests and the many servants and retainers found in these households.

In cooking there are six basic operations when heat is employed in the preparation of food. They are as follows: broiling, roasting, baking, boiling, stewing, and frying. Fundamentally these operations are different in their action and their effect upon the foods subjected to them. Theoretically they are very simple. In practice they require a specialized technique for which some persons have a special aptitude and which others, alas, never acquire. It requires no great stretch of the imagination or of the memory to recollect some of the crimes that are committed in the name of cookery. A recipe, be it ever so clear in phraseology and explicit in direction, does not guarantee a perfect product in the hands of every one who follows it. One cup of butter, two cups of sugar, three cups of flour, and four eggs in the hands of one individual may yield a cake which is a toothsome marvel and the consummation of all the qualities a cake should have while a tyro or a culinary moron may produce an article suggestive of Portland cement or of Para rubber.

Instead of one hour we might spend many in the bewitching byways of the inexhaustible romance of cooking. We might spend a whole hour profitably discussing technique alone. Who has not been fascinated by the sight of griddle cakes deftly turned by the dextrous

operator in the front window of a restaurant? Adroit as these individuals usually are they could scarcely compete with the wife of an early American pioneer, whose pancake proficiency was tested by her ability to toss the cake from the skillet directly up through the broad chimney and run out of doors in time to catch it coming down.

COOKERY'S BYWAYS

Then there is not only the technique of cooking alone, but that of serving and especially of carving. Do you know that one hundred years ago there was a distinctive nomenclature for this latter art? One had to learn to cut up a bustard or a turkey, to souce a capon, to unlace a rabbit, to rear a goose, to unbrace a duck, to wing a partridge, to allay a pheasant. to wing a quail, to lift a swan, or to break a teal.

We might describe the uses of obsolete and discarded culinary utensils, such as spits, warming irons, marble mortars, trenchers, etc. We might comment upon the favorite foods and beverages of noted individuals, for the records show that Kant preferred lentils to rich foods, Goethe champagne to beer, Martin Luther beer to water, Alexander Pope loved cold sliced meat, Frederick the Great and Napoleon were great coffee drinkers, and William Morris, the poet, thanked God for making something as strong as an onion. Haydn, the musician, was in the habit of ordering a dinner for five or six and then devouring the whole of it himself.

Even in our Mother Goose rhymes days we were made acquainted with the preferences of Little Jack Horner, of old King Cole, of the dainty dish of four and twenty blackbirds that was set before the King; of the Queen who ate bread and honey in the parlor, and in the modern classic *When We Were Very Young,* the King's desire for butter on his bread is the motif of one of the most charming jingles in the book. And who can forget the alluring labels "Drink Me" and "Eat Me" which Alice encountered in her wanderings in Wonderland. If we took the time to enumerate odd food substances and peculiar food habits we should have to devote a series of lectures to that subject alone. Brillat-Savarin says of the Romans: "Nothing was left untasted, from the ostrich to the cicada, from the dormouse to the wild boar. They left no experiment untried in their search for appetizing sauces, and successfully employed many substances, the use of which is beyond our understanding."

The catholicity of taste and the daring excursions into unknown realms of culinary possibilities is strangely lacking in our present

age. The John Does and Richard Roes of the present, with all their relations, suffer from food prejudices to an amazing extent. If you don't believe it, try to introduce a new food, not a manufactured product, but a perfectly wholesome, palatable, but unfamiliar food, like the new vegetables dasheen and chayote, upon which our own U. S. department of Agriculture spent thousands of dollars in an ineffectual attempt to popularize them a few years ago. War-time food administrators will remember, too, that many persons would suffer the pangs of hunger rather than eat corn meal when wheat was scarce. Most Americans who travel stop at American hotels in foreign lands and rarely have an opportunity or even a desire to try new foods.

He who would really enjoy foreign travel must be able to eat in all languages. Foreign dishes, like books in a foreign language, lose something by translation into another culinary tongue. There is a society in France which has for its primary object the introduction of new foods and new dishes to its members. It is called the *"Societe Nationale d'Acclimation,"* and its annual banquets afford the members an opportunity to try rare foods and unusual combinations.

In all times and in all climes there have been a few daring souls engaged in pioneer work of this kind, and subsequent generations call them blessed. The tomato and the potato were long looked upon with suspicion by the *hoi polloi;* now they are indispensable articles of our daily dietary. One of the earliest of such societies was called the "Meduse" and was formed in Marseilles, France, during the seventeenth century. There have been societies, too, whose avowed object was the consumption of abnormal quantities of food. In one of these, which existed in France in the eighteenth century, the eligibility rule for membership was the ability to eat for three hours continuously. An outgrowth of this was another society called the *Grands Estemacs* (literally "great stomachs"), whose annual dinners started at six P. M. and lasted until the following noon.

We might multiply instances from history of inordinate individual capacity for food. In this connection one is reminded of the story of an individual who called himself "Egbert the Egg King," who was proud of the accomplishment of being able to consume, at a single sitting, three dozen hen eggs, two dozen duck eggs, and one dozen goose eggs. An agent for a vaudeville circuit called upon Egbert and offered him a place on the circuit. He called Egbert's attention to the fact that he would have to appear twice daily, to

which Egbert readily agreed. When the agent, however, mentioned that on holidays there would be four performances, Egbert demurred. "There is one thing that I want clearly understood," he said, "you must arrange your schedule so that I will have plenty of time for my meals."

We might spend an hour more taking a "cooks' " tour through the fascinating domain of geographical gastronomy. Here we could discuss Philadelphia scrapple and pepperpot, Baltimore terrapin, Southern fried chicken, Boston baked beans, Virginia beaten biscuits, not to mention chop suey, schnitz und knoepf, spaghetti, goulash, curry, gefüllte fisch, English plum pudding, and many other comestibles, the very enumeration of which unconsciously starts the early mechanistic stages of salivary and gastric digestion.

One of the hampering influences of culinary progress in our times is the development of "food faddism." Here we enter the lunatic fringe of culinarophobia, vegetarianism and many other fanatical beliefs and practices. This is not the romance of cookery, it is rather melodrama or tragedy, especially for those who are trying to reduce, and we shall pass it by in silence.

The English have a saying "to dine with Duke Humphrey," which means to go without dinner altogether, the relevancy of the quotation being found in the fact that Duke Humphrey was starved to death in the Tower. Tonight you have dined with Duke Humphrey. I hope you have not suffered overmuch. Whether we call it aliment, diet fare, feed, fodder, food, forage, nourishment, nutriment, pabulum, provender, regimen, sustenance, viands or victuals, we find it playing a great part in human history and in human happiness. Whether one studies astronomy or gastronomy one simply must eat, whether one eats simply or not. Let me close by quoting from an inscription in a cook book sent as a gift:

> "Instead of teaching wives to shoot
> As in the modern day;
> Doc 'Wiley's' maxim 'Feed the brute,'
> Is much the better way."

THE HEART

By Dr. Arno Viehoever

Director of the Biological and Microanalytical Laboratories, and College Experimental Gardens

The Liver is the Seat of Love, The Heart the Organ of Courage.—Galen

A HEART-TO-HEART TALK: The subject far too ambitious for one evening's lecture, was nevertheless chosen for various good reasons. One of them was my desire, after years of study of *Digitalis,* the Heart Stimulant par excellence, to gather data on the heart itself.

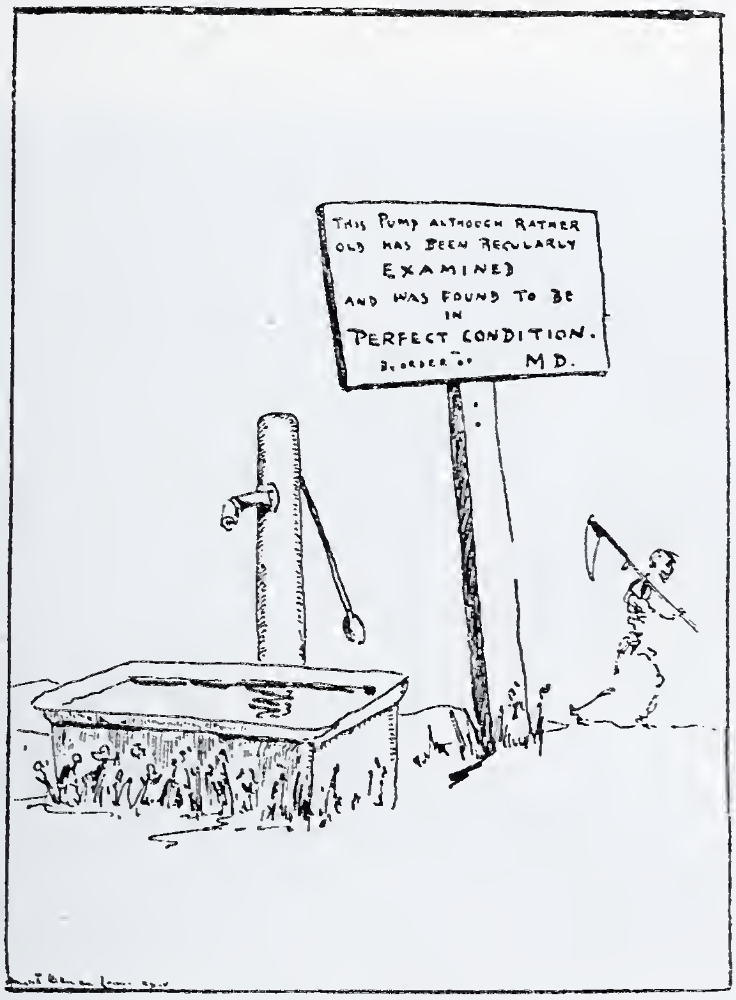
Dr. Arno Viehoever

Through the courtesy of various agencies I have been favored with films,[1] which, I trust, show in a satisfactory manner the animal and especially the human heart at work. Even a brief general discussion should give us all an excellent opportunity to realize the progress that medical art has made in the understanding of the noblest part in man's make-up—the heart. The fact that the heart, the provider of blood circulation, is the center of *life and strength*—now known to many, must become known to all. The beating heart is indeed romantically considered the receiving and sending station of our deep and great emotions. In consequence we find abundant references, such as, The Heart of the Nation (Washington), the heart of this or that city, this or that mountain range. No love story is possible without reference to the heart; we find its daily mention in the public press, on posters and cards. Just remember the pang on Valentine's Day and the hearts that are lost or given away within a few hours. Then there is the "broken heart"—often more costly than painful, the buried heart—the evidence of a once living glory, and the really sick heart, more common among us humans than generally known, in the very forefront of human afflictions.

Great credit is due the associations which have given special attention to Heart Diseases, their causes, their cure and protection. I mention especially the American Heart Association in New York,

[1] These films were demonstrated at the Popular Lecture.

and affiliated organizations such as the Regional Heart Association of New England, the State Heart Associations of Iowa and Pennsylvania, the local Heart Associations of Chicago and Harrisburg, Philadelphia, San Antonio, St. Louis and the Heart Committees of six State, County and Local Medical Associations and of seven health organizations, all disseminating useful information and urging care



Courtesy Survey Graphic.

Fig. 1
Hearts Are Pumps. Drawn by Hendrik Van Loon.

and caution. More general support must be given these activities to benefit the young, the old, the individual family and communities. Many clinics have been established for the exclusive treatment of heart disease, but research into the nature and cure must be further fostered before man is master of his heart.

I

Strong Hearts

THE ENGINE The heart, a living pump, a mechanism controlled by nerves, forces the blood through the human body in unceasing circulation away from it and back again. Its action is similar to the efficient water systems of our cities, more complicated,

more wonderful, with blood vessels instead of water mains, with blood instead of water.

The heart weighs about eight or nine ounces in the normal adult. Sometimes enlarged, due to causes such as over indulgence, this so-called "ox-heart" may weigh thirty and even fifty ounces.

The heart is located in the left chest, and partly enfolded by the lungs. The human heart, like that of other mammals, is divided

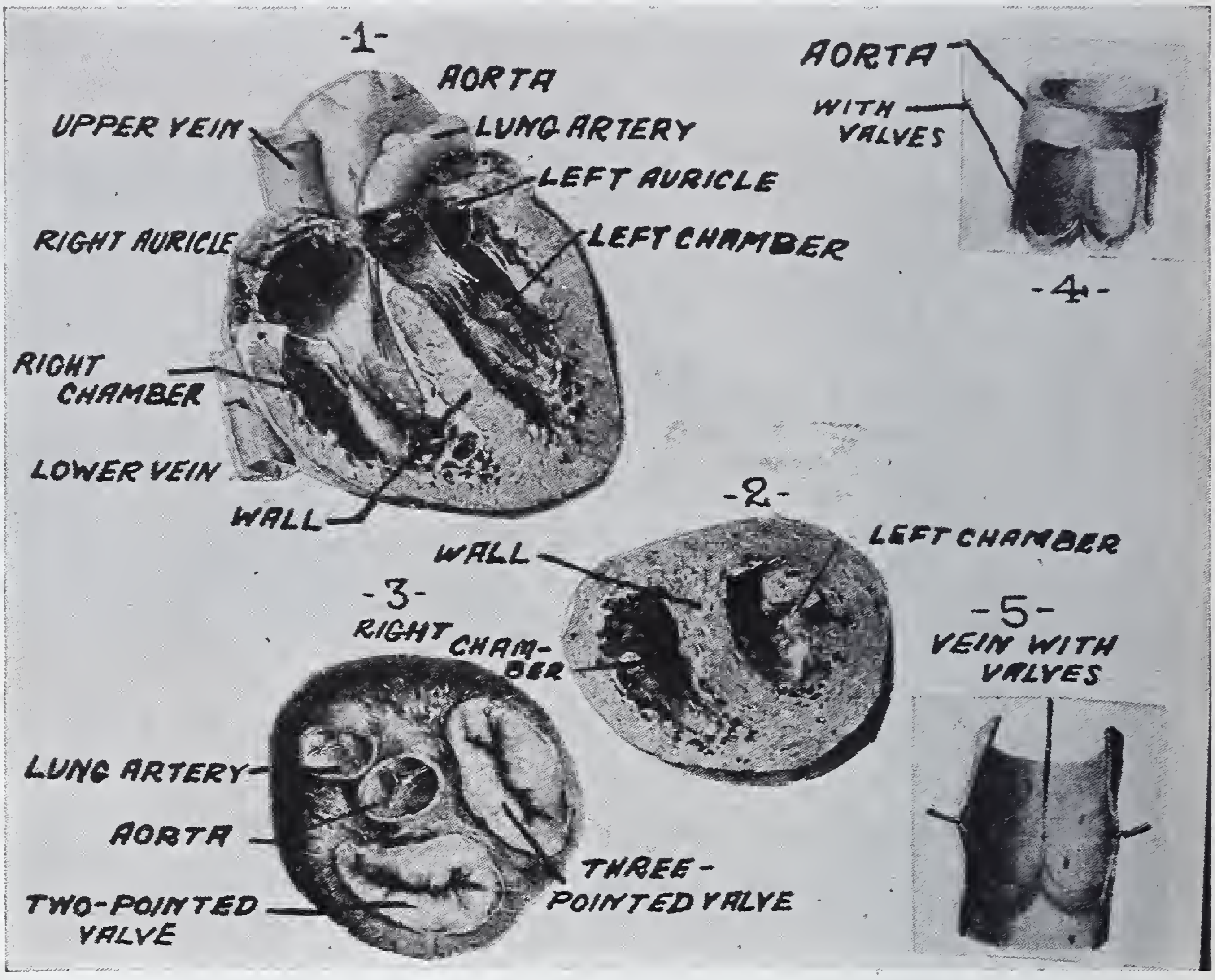


Fig. 2

1. Heart, Opened From the Front. 2. Heart in Cross-section. 3. Heart Contracted, Auricles Removed. Valve Closed. 4. Valves of the Aorta. 5. Valves of the Vein. (After Brockhaus.)

by a muscular wall into two completely separate parts, a right and a left, with two chambers each, acting as pumps. The upper chambers, "atriums" or "auricles," are connected with the lower chambers. "ventricles," by valves. The inner structure of the organ is indeed intricate, like the mechanism of a watch, though a still greater marvel. The valves, acting much like valves in springs, prevent the flow of blood in the wrong direction, in particular, the back flow. A delicate membrane, "the endocardium," lines the interior of the heart.

The heart, placed into the rigid heartsac pericardium, forms together with it a membrane—suction—and pressure pump. This is Hauffe's view, supported by Ohm's Roentgen ray observations. The sac corresponds to the wall of the pump, the successively contracting auricles and ventricles represent the moving pistons; the contraction of the auricle produces a reduction of space in the heart sac, causing a suction of the blood into the ventricle and from there into the arteries.

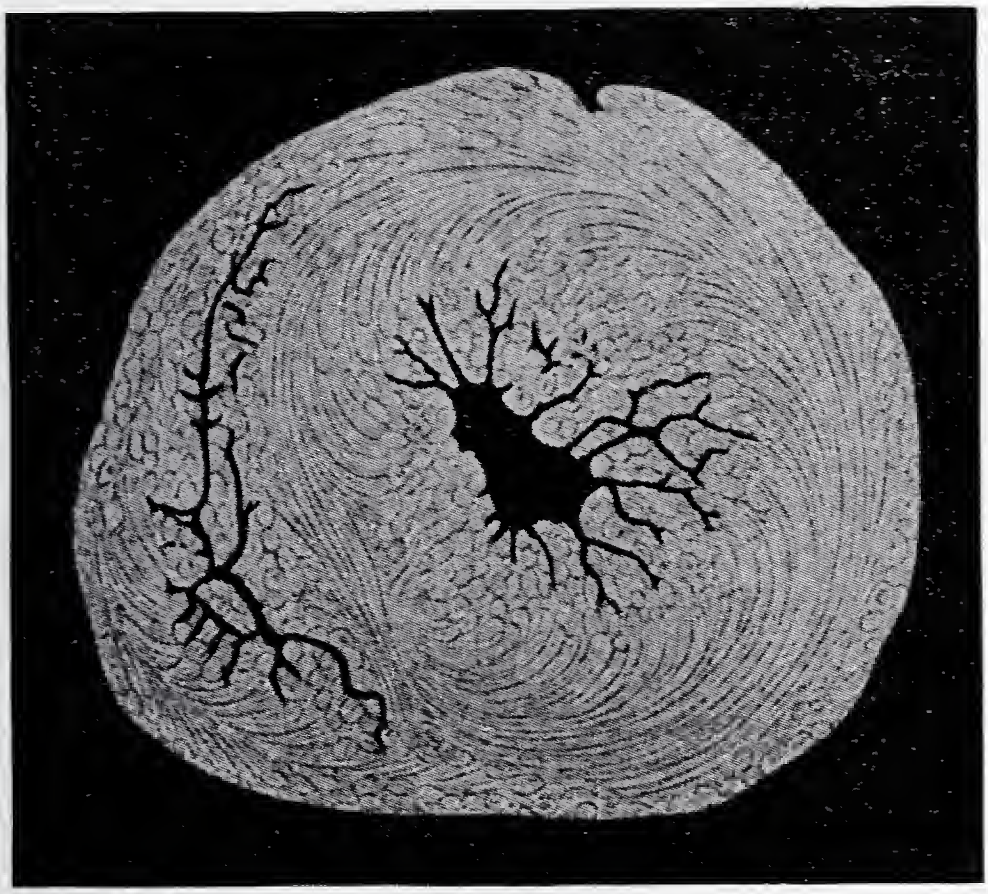


Fig. 3

Completely Contracted Human Heart in Cross-Section Near Lower Third. (After Krehl.)

The heart engine starts running long before actual birth; it beats, pressing periodically against the chest wall, about 150 times in the embryo and on an average of 70-80 times per minute in the adult; it is always at work, its hollow muscle contracting, losing its blood in the systole, and expanding, relaxing and filling itself again in the diastole, independent of our mind and will; hastened and retarded by a multitude of influences; running on without stop, the whole of a lifetime; a most efficient muscular machine that can be repaired only while it is functioning, and that beats on, despite strain or pain, leaking valves and palpitation, until only death ends its ceaseless efforts.

PROPERTIES OF HEART MUSCLE

The heart muscle only reacts if the stimulus is great enough to cause a single maximum contraction, followed by relaxation. A somewhat similar effect may be observed in water dropping from a slowly running spigot only when the weight of the drop exceeds the resistance of the tension existing at the surface. After the heart contraction begins, stimulation has no immediate effect. Due to these characteristics, the heart may beat rhythmically even though it is highly stimulated. Always a hastened rhythmic, rather than a lasting contraction, takes place.

SELFACTION (AUTOMATY) OF THE HEART

A heart may continue to beat, if it is removed from the organism; it must contain, therefore, the cause for the rhythmic beat in itself. Certain parts resembling embryonic muscles respond more readily, spontaneously, to stimulation of the rhythm. In the right upper chamber, at the mouth of the large veins, this tissue, the "sinus node"—the center of rhythmic action, the "pace maker" is found. Another spontaneously reacting node is found between the upper and the lower main chamber. These nodes, connected with a fine set of specific muscle fibers, evidently represent the system that conducts and distributes the stimulation upon the single contractile heart element.

The ramification of the conducting system, according to the cytologist Dr. Wingate Todd, extends throughout the heartsubstance from the entry of the great veins to the terminal expansions in the ventricular walls, passing through the junction of upper and lower chambers in diverse manner by several alternate paths.

The control of the automatic action is exceedingly complicated. Salts of the blood plasma play an important rôle, the effect of one being harmful—if another is absent. An excess of potassiumions may stop the heart, if the excess cannot be compensated by calciumions. Automaty may be produced by stimulation of the sinus, the leading tissue in the upper chamber, by the local application (with filter papers, for instance) of potash solutions. These solutions, when applied to the whole heart, stop its beat.

The explanation of the automaty of the heart may actually be found in the fact that certain substances—hormones—discussed later, are formed in the automatic centers.

CIRCULATION

The blood, in its continuous travel through all parts of the body, provides, among other things, the all-important oxygen. This element, abundant in the atmosphere, more

abundant in the water, a mixture of hydrogen and oxygen, provides for oxidation and thus maintains and sustains the complicated dynamic molecular organization which we call life.

The vessels, which conduct the oxygenated (oxygen-laden) blood from the heart to all parts of the body, are the arteries. The blood flow is intermittent and is regulated by the rhythmical beating of the heart (the flow in the veins is continuous).

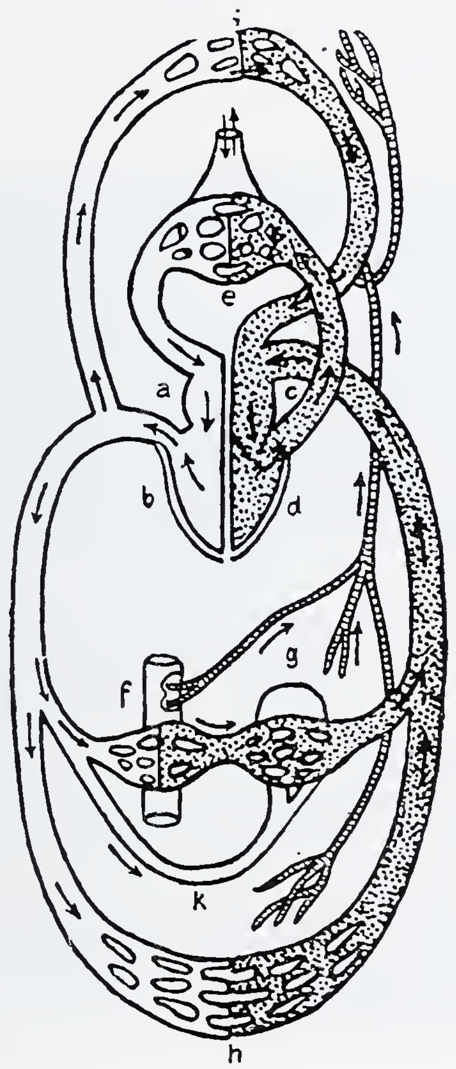


Fig. 4

Blood Circulation—Left Side a: Upper Chamber (Auricle); b: Lower Chamber (Ventricle); Right Side c: Upper Chamber (Auricle); d: Lower Chamber (Ventricle); e: Lung Circulation; f: g: h: Capillaries of Intestines, of Liver, of Lower Extremities; i: Capillaries of Head and Upper Extremities; k: Artery of Liver. (After Tigerstedt.)

The walls of the arteries have to resist a considerable pressure. They must be stronger and more elastic than those of the veins with thinner walls, and a limited number of smooth muscles. Valves are present to prevent the back flow of the blood.

Besides the arteries and veins, numerous capillaries function in the transportation of blood, carrying it among themselves and in the various tissues of the respiratory, digestive and glandular system.

The heart muscle has a private blood supply—the coronary arteries or coronaries, serving the proper nourishment of the heart.

As the muscular wall between the heart partitions is impenetrable, the blood can only reach the left from the right side through the lungs, thus forming the small circulatory system. Through numerous blue veins the blood reaches the right upper chamber. From here the lung artery carries it to the lungs, where it exchanges oxygen for the carbon dioxide excreted from the lungs. From the left chamber the blood runs in the main blood-channel "aorta," which distributes it through many arterial branches to all parts of the body. It is

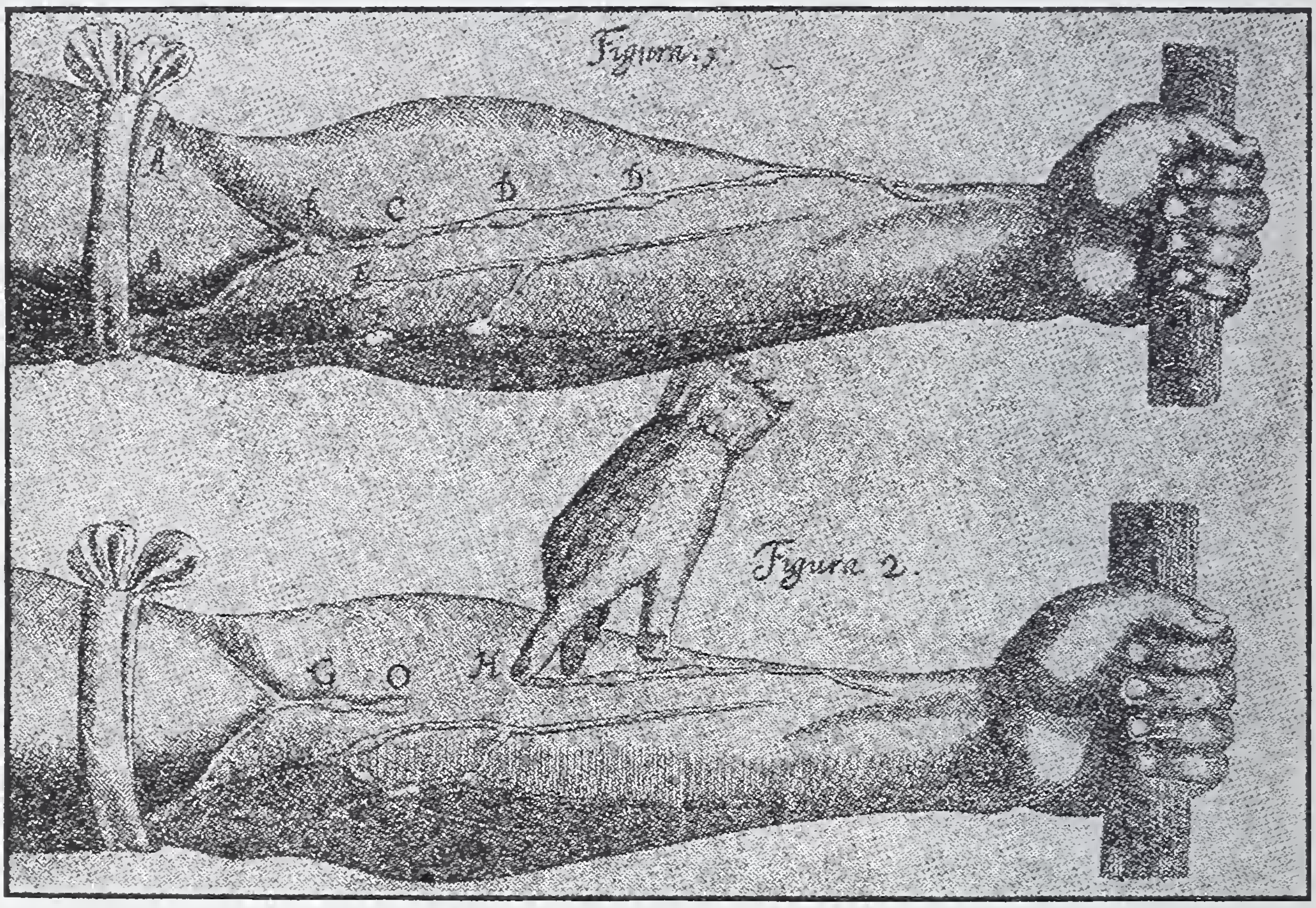


Fig. 5

Harvey's Own Illustration of One of His Experiments With Circulation.

saturated with oxygen and carries this in its progress throughout the closed tube (vascular) system—together with the food elements made available in the digestive system. It collects those decomposition products that are not otherwise taken care of, *i. e.,* excretion through the kidneys and skin, and returns through countless veins to the upper heart chamber, thus forming the large circulatory system, first recognized by Dr. Harvey, exactly 300 years ago.

Harvey described his experiment as follows: Let an arm be tied up above the elbow as if for blood-letting (phlebotomy) (A, A, Fig. 1). At intervals in the course of the veins, especially in laboring

people and those whose veins are large, certain knots or elevations (B, C, D, E, F) will be perceived and this not only at the places where a branch is received (E, F) but also where none enters (C, D): these knots or risings are all formed by valves, which thus show themselves externally. . . . Apply the thumb or finger over a vein in the situation of one of the valves in such a way as to compress, and prevent any blood from passing upwards from the hand; then, with a finger of the other, streak the blood in the vein upwards till it has passed the next valve above, the vessel now remains empty; the finger being removed for an instant, the vein is immediately filled from below; apply the finger again and having in the same manner streaked the blood upwards, again remove the finger below, and again the vessel becomes distended as before; and this repeat, say a thousand times, in a short space of time. And now compute the quantity of blood which you have thus pressed up beyond the valve, and then multiplying the assumed quantity by one thousand, and you will find that so much blood has passed through a certain portion of the vessel; and I do now believe that you will find yourself convinced of the circulation of the blood and its rapid movement.

Dr. Hill, the London authority on muscular movement in man, calculated the amount of blood-circulation and oxygen needed at rest and in action. He concludes that in man of ordinary size (about 150 pounds) the blood circulates through the body about once a minute and carries 4 per cent. (250 ccm.) of the available oxygen in four to five liters of blood. In a man hard at work (*e. g.*, rowing) the amount circulated per minute is enormously increased. The oxygen intake is 4.4 liters per minute, requiring thirty-four liters of blood to carry it. As only about five liters of blood are available in the whole body, the blood must circulate about seven times every minute. Inasmuch as these thirty-four liters go through the right and once through the left side, sixty-eight liters of blood pass the heart per minute, an enormous output for a pump weighing only about one pound. During such activity the heart consumes as much oxygen as the whole body at rest.

HEART NERVES The heart, as all other autonomously innervated organs, has two nerve systems, balanced but antagonistic. When one, vagus, is stimulated, the other, sympathicus, is depressed. The right function of vital processes and the involuntary muscle depends upon the even balance of the two nerve parts.

They work, says Dr. Ellice McDonald, the able Philadelphia physician and investigator, in different ways, the vagus division stimulates the stomach and intestines and slows and weakens (inhibits) the heart, while the sympathetic division increases the heart's action (stimulates) and slows up the stomach and intestines. It is as if the black gang on the ship were in two shifts and has care of two engines. The starboard watch of the black gang (the vagus division) makes the cook's galley and the commissariat (the gastrointestinal tract) work hard, but cuts down steam on the turbines (the heart) and the port watch (the sympathetic division) keeps up steam on the turbines, but cuts down on the cook's galley. But both are necessary to proper running, and if one works more than another, it will go hard with the ship. The proper balance or equilibrium of both sides of the vegetative nervous system is then necessary to the proper balance of the human craft.

Nerve action is associated with chemical conditions of the body and indeed influenced by them. When the liquid around the heart is acid, the heart beats slower (vagus action), when the liquid is alkaline, the heart beats faster (sympathetic action).

BLOOD PRESSURE

Blood pressure means the pressure of the blood against the arterial walls—it is comparable to the air pressure in automobile tires, or the water pressure in a rubber sprinkling hose. The amount of blood pressure, if too low or too high, is readily and painlessly determined in a few minutes by Harvey's method, *i. e.,* by shutting off the pulse in the large artery of the arm.

Normal blood pressure depends on the proper balance of these three factors: the beat of the heart, the elasticity of the arteries, and the resistance to the flow of blood exerted by the smaller blood vessels or capillaries.

Age, sex, and general conditions under which it is taken, influence the blood pressure. It varies during physical exercise, or moments of great emotion.

The normal blood pressure in a man of forty corresponds to about a 130 mm. mercury column, being somewhat lower in a woman, and rises about 4 mm. for every ten years.

It takes about thirty-forty seconds, according to Prof. E. K. Marshall's findings, until an appreciable amount of blood, leaving the lungs through the left heart, returns again to the right heart;

this finding agrees with Hill's statement of amount of blood circulation at rest.

The capillaries of the circulatory system have smooth muscles. Most of the interchange of substances with the blood takes place in these capillaries. Their total length has been estimated at 62,000 miles—a distance equal to two and one-half times the circumference of the world.

The influence of the vegetative nervous system in contracting and filling these capillaries, and its effect upon the nutritional process (metabolism) is indeed great.

The heart, according to Dr. McDonald, pumps normally seven and one-half tons of blood a day—energy sufficient to lift one ton 120 feet high. Under great stress the heart beats faster and harder, the work and the blood pressure being much increased.

Composition

GLYCOGEN The heart muscle, like other muscles, contains as one of its important constituents, glycogen—a carbohydrate. During work this is converted into lactic acid, which disappears again, under the influence of oxygen. The amount and rate of lactic acid production depends on the magnitude and intensity of the effort. The removal is complete in recovery. Dr. Hill suggests that lactic acid might be regarded as a governor of oxidation in the body; the higher its concentration the more rapid the oxidation—the glycogen reappearing possibly as a result of the reaction; lactic acid—hexose, the sugar being then polymerised as glycogen.

SALTS Calcium is needed as the greatest source for the blood supply of alkaline salts. The blood is predominately alkaline, *i. e.*, if this balance is lost and the blood becomes overcharged with acids, health may be so seriously impaired that death may ensue.

The oxygen combines with the red blood pigment, hemoglobin, and is carried as oxy-hemogoblin to the very part where it is needed. It is not stored, as fat is stored in the body, but is carried through the tissues to the last cell of the body, where the oxygen is used to generate the heat necessary for converting food into body-building and energy-supplying elements.

HEART HORMONES

Various authors within the last year or two have proven that substances are present in the heart, continuously formed anew, which we may designate heart hormones. Loewi found that in the surviving heart, upon stimulation of corresponding nerves, substances are formed which produce vagus effects on other hearts. He considered his vagus and sympathicus substances as ester-like bodies which are rapidly decomposed by fermentative hydrolysis in the organism.

Dr. Haberlandt, Professor of Pharmacology in Innsbruck, Austria, has isolated from the unstimulated heart extracts with digitalis-like effects. The active substances, not as yet isolated in pure condition, are soluble in absolute alcohol, and are not proteins, insoluble in ether, and are not fats or lipoids; they are dialysable, stand boiling without damage in contrast to enzymes, and diffuse into Ringer solution from the isolated heart. These substances, as other hormones, are not specific for hearts of different species of animals.

Much progress may safely be expected from this earnest biochemical and physiological search for the very instigators of heart action.

II

Weakened Hearts

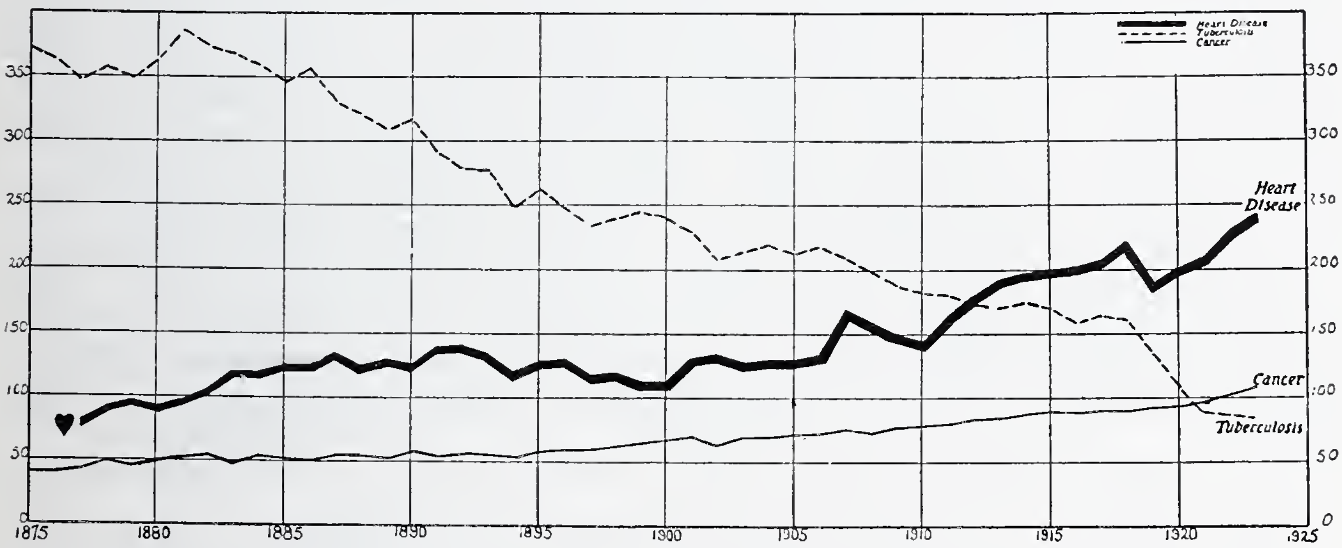
A new order of vigor prevails today in the civilized world, states Dr. Dublin, the statistician of the Metropolitan Life Insurance Company. The control over the external infections, he continues, has resulted in a greater interest in the defects of our internal organism. Today the emphasis is shifting, however, from the infectious diseases of youth to the degenerative conditions of middle life, such as heart disease, the hardening of the arteries, Bright's Disease (nephritis), the nervous disorders and cancer. There is good evidence that these conditions, taken together, are increasing. It is entirely possible that the way we now live has a good deal to do with the situation. The crowding of immense populations into the cities, their intense and noisy activity, the drive for money and for the excitements which money supplies are certainly not conducive to orderly and reposeful living.

HEART TROUBLE

The "nervous heart," not a true heart disease in the strictest sense, according to Drs. White, of Boston, Massachusetts, and Myers, of Des Moines, Iowa, is the common-

est disturbance of all. It represents the condition occurring frequently during convalescence from acute infectious diseases, *e. g.*, the influenza heart, the "pneumonia heart," operations and accidents.

HEART DISEASE Heart disease is listed first in the causes of death, and in the amount of harm and misery it brings through producing disability and invalidism. A recent weekly report of the Philadelphia Bureau of Health showed that the largest number (73) died of heart disease. With a growing record of at least 200 dead for every 100,000 of people in the United States from heart disease, the highest death rate of 250 for every 100,000 popula-



Death Rates from Heart Disease, Tuberculosis and Cancer per 100,000 population in New York City

Fig. 6

tion in big cities, such as New York City, with more than 2,000,000 persons in this country suffering from it, heart disease has become the outstanding health problem. The long period of incapacity, due to this disease, causes a greater economic drain on the community than any other human affliction.

Certain very common disorders of the heart, recorded as functional, arise from difficulties outside the heart. Although we observe no change in structure, walls or valves, the heart is not working properly. The nervous system regulating the heart action may be temporarily disturbed by sudden noises, extreme bodily exercise, nervous exhaustion and overstrain, creating depressing symptoms, usually of no great importance—unless the disturbance continues and impairs the heart permanently.

Organic heart diseases involve some change in the heart itself and are much more serious disorders.

SYMPTOMS

To fix the symptoms which may be observed, Dr. T. St. Hart, former president of the Association for the Prevention and Relief of Heart Disease, asks those who have sound hearts to try the following experiment: Tomorrow when you are going downtown via the elevated railroad, start to run about two blocks before you reach the station, rush up the stairs as rapidly as possible and tumble into a seat on the train and proceed to observe your own symptoms: (1) you will be "all in" and feel a general sense of fatigue and weariness; (2) you will be conscious of a pounding, thumping heart, *i. e.*, palpitation; (3) you will be short of breath and puffy, *i. e.*, dyspnea; (4) if you count your pulse rate you will find it quite rapid, *i. e.*, tachycardia. These are the outstanding symptoms of a heart that is working in response to stress; fatigue, palpitation, dyspnea and tachycardia. In a few minutes your normal heart will recover its normal activity, fatigue will disappear, you will not be conscious of your heart action. Your breathing will be quiet, and your pulse slow. The functionally abnormal heart will develop the same symptoms, but the amount of effort which calls them forth is quite different. Slowly climbing half a dozen stairs may be sufficient to make all these signs evident, and they may not disappear for a long time. In a badly damaged heart these symptoms may persist even when the patient is making no effort and merely sitting in a chair or lying in bed. With the improvement of the heart condition it will require more and more effort to induce these evidences of a laboring heart.

CAUSES

Heart disease may be caused before birth (congenital), through faulty development of heart structures—or acquired after birth through an infection, through the absorption of a toxic substance (food-toxin or poisonous metal), or finally through degeneration as a result of over-exertion, over-indulgence—and old age.

The congenital heart disease, while rather rare, in comparison with the number of other heart diseases, is comparatively frequent in certain children's heart clinics.

An examination of 856 adult patients as reported by the American Heart Association showed the following relative causes of heart disease:

Unidentified	10%
Various causes	15%
Rheumatism	25%
Syphilis	10%
Arterio Sclerosis (hardening of the arteries.)	40%

While many factors other than infection are the cause of heart failure in adults, infection is singularly considered as the cause of heart failure in children.

In the northern and eastern States, according to the review of about 1000 cases of heart disease by Dr. C. T. Stone of Galveston, Texas, rheumatic fever is less frequent, and the occurrence of rheumatic heart disease is correspondingly reduced. Hypertensive heart disease is the most common type along the Gulf Coast. In the clinic of the John Sealy Hospital, syphilitic heart disease is second in order of frequency, doubtless due to the large number of negro patients. Cases of rheumatic heart disease often occur in typical form without history of a preceding attack of rheumatic fever or chorea. Syphilitic heart disease is found most often in negro males in hard manual labor. It is distinctly less frequent in the white race and in females of the negro race.

RHEUMATIC HEART

Rheumatic disease in the child is indeed a menace. Rheumatism, Dr. St. Lawrence, noted child specialist of New York, stated at the last annual meeting of the Heart Association, is the chief and perhaps the sole cause of heart disease in children. Like tuberculosis, it displays the same permanency with periods of quiescence and recurrence—and repeated examinations are necessary to ascertain that the infection has been eliminated, no damage done and no disorder remaining. There is evidence, though not fully verified, that we are dealing in rheumatism with germs, or their poison, that attack the joints, the nervous system, the muscles, including the heart.

(1) Rheumatic fever is characterized by red, swollen and painful joints.

(2) Rheumatic heart trouble is usually acute—occurs early in life, and often affects the valve between auricle and ventricle on the left side.

(3) St. Vitus' Dance (chorea) and growing pains are looked upon as rheumatic troubles leading to heart disease.

(4) It is considered likely that rheumatic germs enter the body through diseased tonsils, adenoids and decayed teeth. Removal of these conditions is therefore accepted as an effective measure.

A careful analysis of 478 cases of heart disease—reported by Dr. Morris Fishbein, the editor of *Hygeia* and other medical journals—showed that in 83 per cent. the condition developed before removal of the tonsils, and in only 17 per cent. after their removal.

SYPHILITIC HEART

The virus of the syphilitic disease frequently attacks the heart muscle in the later stages of infection, causing serious chronic heart trouble many years after the infection. People between forty and sixty are especially afflicted, according to Dr. Dublin; the aorta or aortic valve on the right side of the heart is affected. The affected valves in such cases become scarred and deformed and no longer function perfectly. The inflow of blood from one chamber to another may be impeded, or an incompletely closed valve may permit blood, once through, to leak back into the chamber whence it obviously came. To meet the body's needs, the heart must increase its labor under such conditions and ultimately the muscle will become exhausted. Frequently valvular disease is accompanied by certain unusual sounds called "heart murmur," or murmurs heard in the heart as the blood flows through from chamber to chamber.

ARTERIO-SCLEROSIS

As the various membranes of the normally elastic arterial tubes become inflamed and this inflammation becomes chronic, calcification, that is, hardening and crumbling of the walls (arterio-sclerosis) takes place. The largest artery, the aorta, shows this inflammation first, and later almost all the arteries, in different degrees, become inflamed. The inner membrane of the arteries, according to Dr. R. Schmitt, Director of the Children's Clinic at Hamburg, Germany, becomes thickened by diffusion or flakelike deposited substances, but then undergoes a fatty metamorphosis and becomes softened. The blood, passing this softened inner membrane, causes the formation of ulcers which may again close up. The fatty degeneration now attacks the middle arterial membrane; this loses its elasticity and no longer adequately withstands the pressure of the blood, and the diseased arteries become elongated and twisted, changing their forms, and smaller arteries as a result, may burst, causing apoplexy and bleeding of the brain. In the inflamed arteries frequently lime is deposited, harden-

ing them and making them still less elastic. Primary calcification of arteries without inflammation is uncertain. The closing of arterial branches in brain, heart, spleen, kidney and of main arteries in intestines and mesenterium leads to the death of the tissue. The arteries may be frquently translocated as the walls become thickened and blood clots (thromboses) are formed, stopping blood circulation. Chronic arterio-sclerosis is a typical disease of elderly people. However, syphilis and gout bring calcification in younger years and even excessive smoking and drinking have a hardening influence upon the development of arterio-sclerosis.

Everything must be done by those who suffer from it to prevent great increase in blood pressure and the danger of bursting the arteries.

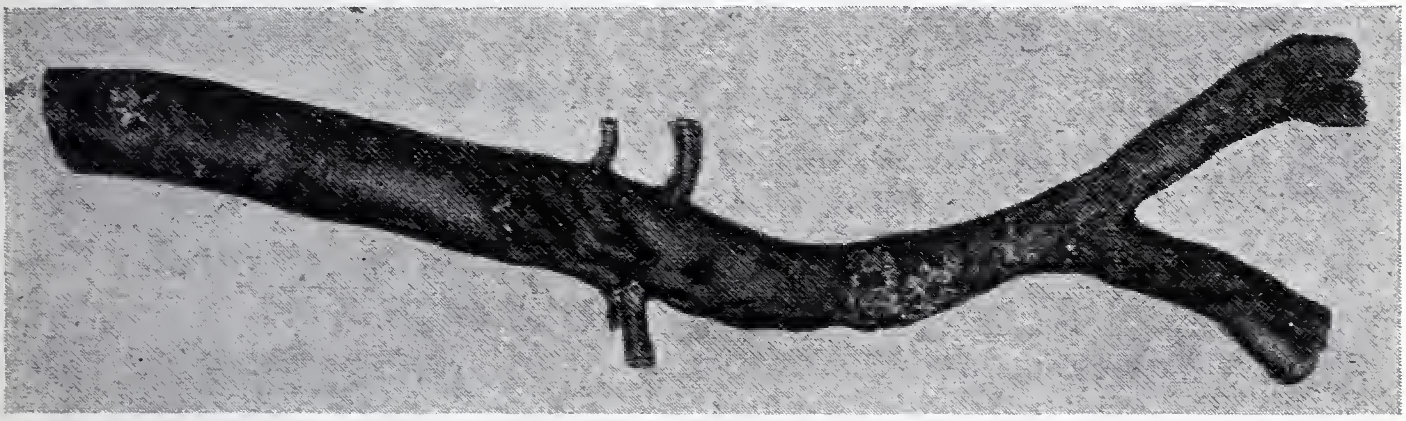


Fig. 7
Calcified Main Artery (Aorta) With the Two Arteries of the Hips and Other Branch Arteries. (After Schmitt.)

BRIGHT'S DISEASE

Increased blood pressure (hypertension), the result of nephritis or of causes unknown, increases the load upon the heart, enlarges and degenerates the heart muscle, without involving as a rule the valves in the beginning of the trouble. This disease, according to Dr. Dublin, is chronic and occurs mostly in old people and in persons after fifty years of age.

ANGINA PECTORIS

If the normal blood supply through the coronary arteries is not available, on account of the degeneration and decrease in size (arterio-sclerosis) of coronaries and arteries, or if, through some disturbance of the general metabolism the heart is not properly nourished, the trouble recognized as angina pectoris, oppressive pain, accompanied by fear, frequently results. Finally death occurs, if the coronaries become plugged and the heart starves.

BACTERIAL INFECTION OF HEART MEMBRANES (ENDOCARDITIS) This disease, according to White and Myers, is due to the invasion of known organisms mainly of the round coccus type and includes the coccus of gonorrhœa and the influenza bacillus. Depending upon the virulence of the organisms, the infection may last days or months or may be fatal, being often not recognized clinically.

OTHER INFECTIOUS HEART DISEASES Scarlet fever heart, according to these authors, is also referred to as rheumatic heart disease. Diphtheritic heart disease is usually fatal. Tubercular heart disease is rare.

GLANDULAR HEART DISEASE Thyroid heart disease may occur incident to insufficient or excessive excretion of the thyroid glands.

TOXIC HEART DISEASE Toxic conditions may be caused by metallic poisons, uremia, possibly nicotine from tobacco, caffeine from coffee and absorption of toxins from local infections. As the poisons are usually slowly absorbed, it is highly important, according to Dr. Wyckoff, to eliminate the poison through improved digestion and to constantly guard against the entrance of outside poisons such as lead, alcohol, nicotine.

OVERSTRAINED AND SENESCENT HEART Excessive athletic exercise may cause the "athletic" heart, excessive beer drinking the "beer" heart, extreme obesity may cause other not well-defined discomforts and trouble. The senescent heart, merely through the degenerative changes in the heart and blood vessels, and not necessarily through any local disease process, refuses to function properly and finally stops entirely because the cells can no longer be regenerated.

III

Treated Hearts

GENERAL CARE It is quite certain, said the British authority, Sir Arthur Newsholme, that a high proportion of the total deaths due to heart disease are preventable, the best way to diminish it is to double public health expenditure, wisely directed toward increased child hygiene, increased school hygiene and increased adolescent hygiene.

In 1921 there was expended in the United States an average per capita of $10 for candy, $9 for education, fifty cents for chewing gum and twenty-nine cents for health.

In the majority of instances, says Dr. Hart, heart disease under suitable management is not progressive. Even if a valve has been injured beyond the possibility of complete repair, proper care may prevent further mischief, and compensating factors may be developed which allow the heart to perform its work efficiently in spite of its handicap.

A number of those having heart disease make a complete recovery and regain health. There are others with damaged hearts who would suffer very little or no incapacity if they would secure good advice and adapt their mode of life to accord with the rules which long study and wide experience have proved effective.

There is altogether too much pessimism in regard to heart disease, suggests Dr. Hart, and pleads that if we are to secure the best results in our patients we must instill them with hope. A patient who is confident of his prospective improvement is far more likely to reach that goal.

There are a number of heart abnormalities that cause much worry and distress which may completely disappear. Such, for example, are certain irregularities as those caused by the excessive use of tobacco. There are on record a certain number of congenital defects, which time has cured. The number is enormous, he concludes, of cases of established heart disease which either never show any functional failure, or which, having once failed to carry on, can under suitable conditions be brought to a high degree of efficiency.

No one else can do so much for your heart as you can, says the Metropolitan Life Insurance Company. Keep it healthy by going to your doctor for a health examination, by looking after infected tonsils or teeth, by eating the right amount of the right foods, by keeping your body weight near the health average, by not over-using tobacco or stimulants.

HEART RULES

The Chicago Heart Association suggests the following fundamental rules in the treatment of heart disease:

Every person with organic heart disease should limit his physical activities. He should consult his physician for a detailed plan.

Amusement and work must be chosen with a view to these limitations.

He should try to avoid situations which are likely to induce emotional excitement.

A person with organic heart disease should spend not less than ten hours out of every twenty-four in bed.

A vacation with relief from work and worry is a good thing for everyone, especially for the cardiacs (those who suffer from heart disease).

A simple, plain diet, containing a variety of foods, is best fitted to his needs.

Unless ordered for him by a physician, he should not use stimulants, such as tea, coffee, alcohol and tobacco.

CONVALESCENT HEARTS Heart disease has so many grades and is so prevalent in all the zones of life that surely considerable numbers should be convalesced regularly in the larger standard homes, along with others.

Three examples of feasibility are suggested by Dr. Frederic Brush, Medical Director, The Burke Foundation, White Plains, N. Y.

(a) Those with fair compensations and reserves should not (as now) be refused because labeled "Heart disease," a "murmur," etc., when needing (as so often) convalescence for other reasons, or merely general upbuilding.

(b) Those who just "tire on the job" frequently, with fairly holding compensations, should be given periodic rests, and in this way kept in productive life.

(c) Youth should be given first place in cardiac convalescence, and more beds opened to them. Youth is to be the main point of attack on heart disease. Recent experiments of the Burke Foundation and others show, apparently, that country convalescence of cardiac youths is surprisingly successful, and without very special equipment or precautions.

These three phases have been entered on. Cardiacs recovering from recent attacks should not be sent early to standard convalescent homes. They relapse too frequently. Prolonged hospital or house care and follow with ambulatory attachment to "Cardiac clinics," and occupational supervision is to be provided.

SPECIFIC CARE The most important relief in the treatment of acute or chronic heart disease, from other than drugs, comes, according to Dr. White, from rest and mental and physical recreation, from wise exercise, favorable climate, friendly psychic

treatment on part of physician and nurse, right physical therapy, adequate regulation of diet and fluid ingested, from successful surgical intervention and venesection.

It seems so strange, says Dr. John Wyckoff, that one patient having heart disease is ordered to exercise, while another one is advised to take absolute rest, although the symptoms in both patients may be similar or even the same.

This can be made clear from the following example, using normal athletes as an example. Three healthy young men enter college at the same time. At the time they enter all three are able to climb four flights of stairs without breathlessness. A becomes very interested in his studies and, although he has previously led a very active life, now leads a sedentary life and takes no exercise. B goes into training for cross-country running and under proper training takes a proper amount of exercise. C leads a life similar to the one they had all lived before entering college. At the end of three months A becomes breathless on climbing a single flight of stairs because he has had too little exercise. C still can climb four flights without breathlessness; but B, who has been training, can now climb six flights before he notices shortness of breath. In other words, B has increased the ability of his heart to do work, by proper exercise. Now let us take our illustration a little farther. B is so enthusiastic over his athletics that he over-exercises and soon he finds that he is getting breathless at four flights; he thinks this is because he is not doing enough exercise and he works all the harder; but to his chagrin, after a few weeks his condition is as bad as A's, he gets breathless now after two flights. The trainer tells him he is "stale," but what has happened is that he has given his heart too much to do. In order to keep a normal heart at its highest efficiency a proper amount of exercise and rest is necessary. This is also true of the diseased heart.

Fine judgment is frequently needed to determine whether a diseased heart needs more or less exercise. Some patients with heart disease should not exercise at all, others need considerable exercise, and this can only be determined by careful study of each case by a physician of experience.

MEDICATED HEARTS

It is much easier to write upon a disease than upon a remedy, wrote the English Dr. Withering way back in 1785. "The former is in the hands of nature, and a faithful observer, with an eye of tolerable judgment, cannot fail to

delineate a likeness. The latter will ever be subject to the whims, the inaccuracies and the blunders of mankind."

In derangement of circulation, the intelligent application of medicinal measures is pointed out by Drs. Levy and Mackie as an important factor in initiating improvement; their timely use is frequently held responsible for the saving of life.

ALCOHOL

A little wine—said President Dr. Samuel Waldron Lambert of the New York Academy of Medicine to colleagues, assembled at a recent conference on old age—for the stomach's sake represents a real therapeutic result, it has an action not on the stomach but on its nearest neighbor, the heart. Alcohol is not a direct stimulant but acts directly as an antidote to the chronic poisoning of the heart from over-indulgence in coffee and tobacco. Alcohol, by its rapid absorption without the necessity of previous digestion, by its action to increase the amount of blood circulating in the capillaries of the skin, gives a feeling of distinct warmth and comfort to the aged. It is particularly true in the diabetes of old age (brought about by greatly increased sugar consumption—in want of the rapidly oxidizable, prohibited, food alcohol) that alcohol has a useful and prominent place in the treatment of disease.

DIGITALIS AND DIGITALOID DRUGS

One of the most important drugs in the materia medica is Digitalis, the beautiful red foxglove, introduced by Dr. Withering from folklore's mysterious concoction to physician's stand-by medicine.

Digitalin and physiologically similar (Digitaloid) drugs, *e. g.*, strophanthus, squill, convallaria (lily of the valley) and apocynum—have the recognized main actions.

Main action of Digitaloid drugs (according to McGuigan):

1. Specific stimulating action on heart, rendering it more irritable, with tendency to more rapid action.
2. Stimulation of vagus nerve center tending to slow the heart.
3. Stimulation of the vasoconstrictor center, causing constriction of the blood vessels.
4. Direct stimulation of musculature of the vessel particularly strong in the visceral (splanchnic) region.
5. An irritant action on the stomach or wherever applied.
6. A tonic action on the central nervous system.
7. A tonic action on the inner lining (endothelial) and lymph conveying tissues.

8. A direct stimulating action on the vomiting center.
9. A marked increase, through changes in the blood circulation, of urine excretion in cases of certain swellings (œdema) in the connective tissue.

The chemistry and physiology of the representative member Digitalis has been a most difficult and trying problem. From recent progress made both for the seeds and the leaves, and from the serious efforts made in various sectors of the world to conquer the difficulties, we may expect soon rather a complete solution. The seeds yield digitalin, possibly identical with bigitalin, digitalein, possibly a mixture of bigitalin and gitalin, and according to my own findings

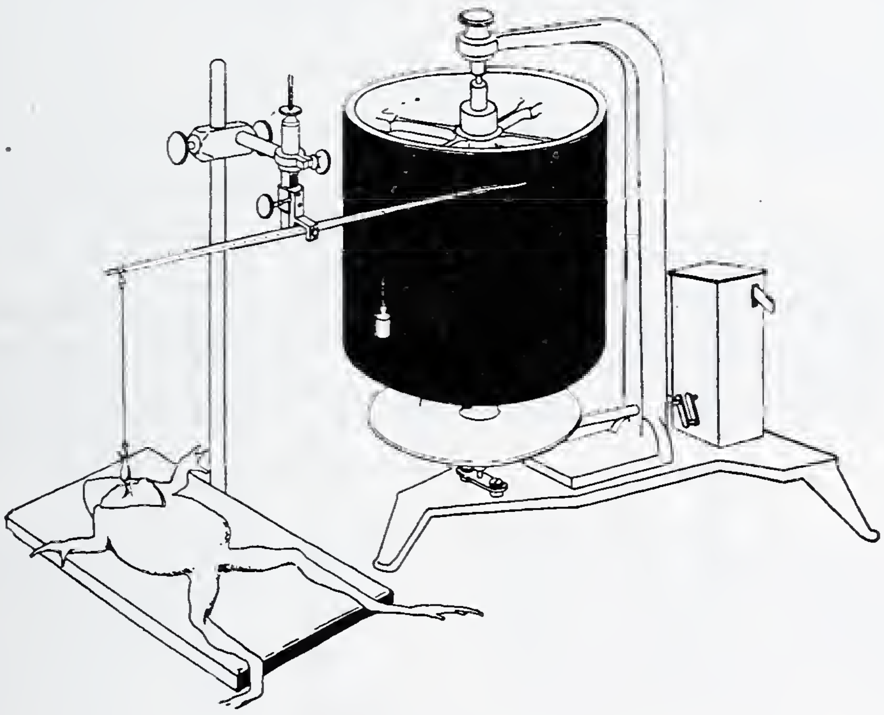


Fig. 8
Suspension Method of Recording Heart Contractions.
(After Abderhalden.)

only traces of digitoxin; the leaves contain, according to latest reports—digitoxin, bigitalin, gitalin and possibly also their products of decomposition (hydrolysis), the genins, and sugars.

STANDARDIZATION The large variation in the amount of active constituents in commercial crude samples and preparations require a definite checkup, "assay." Chemical assay methods are not as yet feasible. The biological test, as ascertaining the strength by the use of animals, "although far from ideal"—as pointed out by Drs. Levy and Mackie and others, is more and more accepted as a worthy check. The pulsations of the strong, weakened

ACTIVE SUBSTANCES OF DIGITALIS

— LEAF —

Substance (Glucoside)	Molecular Composition	Melting Point	Split Product	Molecular Composition	Melting Point	Molecules Sugar	Molecular Composition	Melting Point
Digitoxin	$C_{44}H_{70}O_{14}$	252°	Digitoxigenin	$C_{24}H_{36}O_4$		2 Digitoxose	$C_6H_{12}O_4$	110°
Bigitalin	$C_{40}H_{64}O_{14}$	282°	Bigitaligenin	$C_{22}H_{34}O_5$	232°	3 Digitoxose	$C_6H_{12}O_4$	110°
Gitalin	$C_{17}H_{28}O_6$	245°	Gitaligenin	$C_{11}H_{18}O_3$	222°	1 Digitoxose	$C_6H_{12}O_4$	110°

— SEED —

Substance (Glucoside)	Molecular Composition	Melting Point	Split Product	Molecular Composition	Melting Point	Molecules Sugar	Molecular Composition	Melting Point
Digitalin	$C_{37}H_{58}O_{14}$		Digitaligenin	$C_{24}H_{32}O_3$		Digitalose, Glucose	$C_6H_{12}O_{16}$	
Digitoxin	$C_{44}H_{70}O_{14}$	252°	Digitoxigenin	$C_{24}H_{36}O_4$		2 Digitoxose	$C_6H_{12}O_4$	110°

and medicated hearts may be readily recorded on the kimograph, provided with a rotating smoked drum.

The various animals have been proposed:

1. FROGS

(a) Used in the "one hour method" official in the U. S. Pharmacopœia and National Formulary, for heart stimulants, determining the smaller dose of the drug (per gram weight of the frog) causing permanent contraction of the heart chambers (ventricle) at the end of an hour.

(b) Recommended by Houghton in the twelve hour method, determining the smallest amount per gram body weight causing death of the animal within 12 hours.

(c) Suggested by Focke in his method determining the dose and time required between 7 and 15 minutes to stop contraction of the exposed heart upon injection of the infused leaf into the sac of each leg.

(d) Used in the perfusion method, determining the effect of the test solution upon the exposed heart, suspended by the tip and connected with a lever permitting a graphic record of the movement of the heart on the smoked drum of a Kimograph (see Fig. 9).

2. GUINEA PIGS

Recommended by Reed and Vanderkleed and made official for the testing of heart depressants, determining the smallest dose per gram body-weight, injected under the skin, stopping the heart within 6 hours.

3. CATS

Suggested by Hatcher & Brady, in their method determining the smallest dose per kilogram of cat injected into a vein in the leg or thigh, stopping the heart.

4. GOLD FISH

Proposed by Pittenger and Vanderkleed, determining the smallest amount of digitalis tincture in 500 cubic cc. meters of tap water at 22 degrees Celsius—which proves fatal to goldfish within 3 hours.

5. DAPHNIA (WATER FLEA)

Suggested by Arno Viehoever and under further investigation, determining the quantitative effect of digitalis—extract and isolated active substances upon the heart action, directly visible under the microscope—and the smallest amount, causing permanent stopping in a given time unit under controlled conditions.

The belief has been expressed that the heart hormones found in the center of the rhythmic movement act similarly to digitalis glucosides or vice versa. The isolation of pure substances will greatly facilitate the study. It is now under way.*

In the meantime fruitful work has been done with another hormone, adrenaline, isolated from the suprarenal glands. It hastens heart action on account of the great contraction of vessels. The amount of blood, pressed out of the heart, is much below normal;

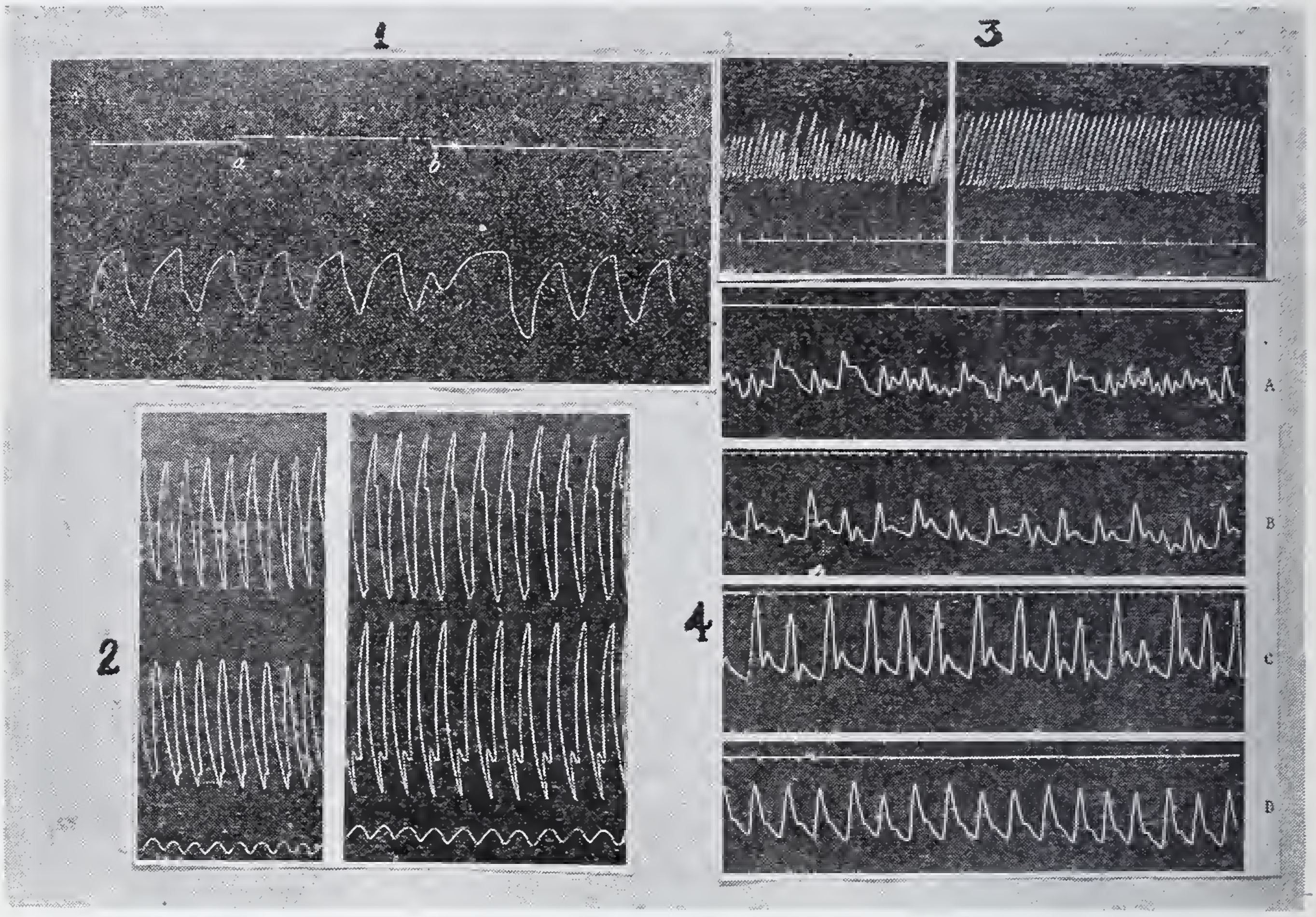


Fig. 9

1. Direct Stimulation of Isolated Rabbit Heart. Stimulation at a., in Beginning of Contraction, Systole, Ineffective. Stimulation at b., in the Midst of Relaxation (Diastole) Causes Extra Contraction. (After Langendorff.)

2. Dog's Heart Before and After Injection of Digitoxin Into the Veins. Cardiographic Tracings of Ventricle (Highest). Cardiographic Tracings of Auricle (Middle). Cardiographic Tracings of Blood Pressure (Lower). The Heart is Lowered (From 205 to 165), Contraction is Increased While Relaxation is Less Increased. Blood Pressure Shows a Slight Rise. (After Cushing.)

3. Rabbit's Heart Before and After Treatment With Digitoxin, Improving the Irregularity (Extra Contractions). (After Gottlieb and Magnus.)

4. Record of Irregular Human Heart, Before and After Treatment With Digitaline. a. Pulse Before Treatment; b. After Four Days Treatment; c. After Nine Days Treatment; d. After Seventeen Days Treatment. (After Pfaff.)

*The author has been supported in the work on heart medicines by grants of the American Pharmaceutical Association and the Kilmer Research Fund, made available to his student coworkers. Additional funds would greatly help speedier progress.

.0,000,0001 of adrenaline is said to contract the arteries of the heart. The effect of one injection is of rather short duration—and ephedrine, the base isolated from an old Chinese herb medicine, Ephedra, has recently been substituted on account of its prolonged action.

The revivification of a weak or even dead heart belongs in the most interesting chapters of medical treatment, though the results thus far have rarely, if ever, been lasting.

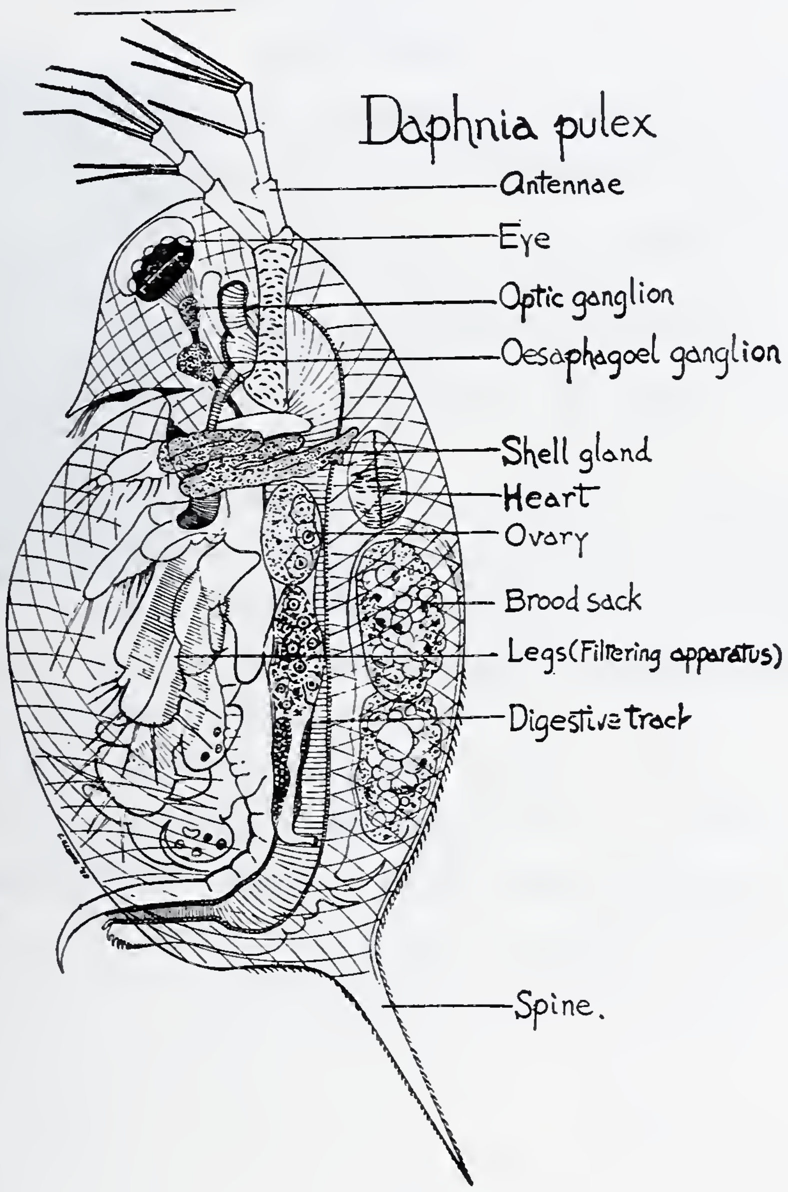


Fig. 10.

RESEARCH "The work of man's redemption of man is yet incomplete." There is clearly a call, believes Dr. Dublin, for a revaluation of the effort now being expended on the study of heart diseases, and for the statement of a program of research, . . . commensurate with the importance of these diseases as sources of preventable or postponable death. The most important need at the present time, states Harry L. Hopkins, of New York, in his "Cardiac Program in a Large City," is much more definite information in reference to heart disease, and for this reason a

very considerable part of the Heart Committee's budget is used for research work, guided by the Committee on Research.

Informed of the complexity of heart troubles and diseases, of the need for further data all along the line, of the serious and rapid increase in heart failures, humanity, as a whole, should join hands in encouraging and supporting the most extensive study of the trying unsolved problems, for its own sake.

Outlook

Statisticians will pile up further useful data to demonstrate and reiterate that heart disease is our outstanding health problem, the leading cause of death.

However, enough information is already at hand to impress upon everyone, child, adult, the aged, the ever-present danger of heart trouble—and the need for sound living, for preventive and curative medication.

The educational work, so effectively set into motion by the Heart Association, will likely increase, as will the helpful work of the heart clinics and individual practitioners.

Behind the stage will be the workers, trying to solve all pending problems of causes and effects upon the heart, the experimenters trying to gain further insight into the intricate structure, to obtain further knowledge of its interrelated activities and better understanding of its magic power of adjustment—all doers eagerly searching for the master key—the key to gain entrance to the living heart of man—and thus to the very heart of life.

THE REALM OF THE x-RAY

By Ivor Griffith, P. D., Ph. M.

Assistant Professor of Pharmacy, Philadelphia College of Pharmacy and Science; Editor, American Journal of Pharmacy

MANY YEARS AGO—a very gullible little fellow sat on a high-backed wooden bench somewhat acutely angled, in a far-away country church, and actually listened to the preacher. No longer had the odds and ends of tin boxes and buttons and dried wild plums which he generally freighted to church to while the hours away—no longer had these things any charm for him—for the preacher had captured his eye and his attention, too. Nor was that to be wondered at, for the pious old gentleman had come that morning with a burning, vitriolic message. Some village Hampden—wide-awake in sin, had brought disgrace to the little hillside hamlet, through stealing a sheep from another's fold—and the time was yellow-ripe for a red-hot sermon on sin and Satan.

Ivor Griffith, P. D., Ph. M.

And the very gullible little fellow for the nonce was all ears. He could hardly keep from applauding. Here was volcanic ash and streaming, fuming lava—sulphur—sulphur burning bright—all hell revealed as he had never heard it revealed before. Not Dante's Inferno nor any other blistering book of adventure in Satan's empyreumatic realm could have been more thrilling and realistic than this eloquent minister's presentation of a militant gospel.

Yet, even then, the very gullible little fellow wondered how it came that such a pious preacher had so much first-hand information about that mysterious scorching kingdom, whence according to Shakespeare and Omar and everybody else "no traveller ever returneth." Perhaps he was simply repeating something that somebody else had said or had written about in books.

And somehow or another, all of this came back to the very gullible little lad, now grown tall, when he sat down to the work of telling something about the Realm of the x-Ray. Perhaps it came back to him because he felt himself in much the same predica-

ment as the old saint did with his Hell. For he, too, had nothing original to tell—only a repetition of something that somebody else had said or had written about in books, yet he hopes for a bit of the old preacher's mantle of eloquence and sincerity and ability to make his message intelligible.

Still it is not for my listeners to think that the Realm of the x-Ray bears too close a comparison with the fantastic realm into whose fierce fires that preacher would cast all stealers of sheep and similar atrocious criminals.

No indeed—for the Realm of the x-Ray is real—very real. True there are some very hypothetical departments to it—much territory that is unexplored—but enough of its domain has been studied and charted to impress us with its wealth of wonders.

And so we leave the old preacher and the burning question—yet wondering in passing if hell were still the fashion—and sheep stealers continued to atone for their sins in baths of burning brimstone would a thermite dip or eternity spent in an electric furnace suffice such criminals as this generation pets and pampers?

To the eternal credit of the old-fashioned hell, it can be happily said that it brooked no board of alienists; it had no mixed juries, and lawyers who dabbled in evolution had no chance in the world to cheat it of its victims. It was a good old Hell and we miss it.

I warn those who would go with me into the land of the x-Ray that it takes more than our customary sense to appreciate the joys of that kingdom. For it is a land of low visibility—and the organs wherewith we see—are not yet evolved sufficiently to appreciate unaided, the things that are in this realm of x-Ray.

Perhaps it is not in the design of things for our several senses to become any more evolved than they are in most of us, pattern-made mollycoddles. I say "most of us" advisedly, for to a few it is given to have some special sense so highly developed as to set that individual quite apart from the average run of humans.

BEYOND THE NORMAL SENSE RANGE

The cubist and the futuristic in the field of picturization can see things—and interpret things in such a way that only confounds the ordinary mortal. What normal being has visited an exhibition of such kind without having been made happy with normalcy. When an artist's sense of sight becomes so enamored of angles that curves hide with sudden

shame—it is no wonder that his delineation of "A Street Scene in Simla"—looks to normal beings like a score of clothespegs dancing on a corrugated wash board.

Yet it is a natural broadening of this same sense of vision and a kindred acuity of form and of color interpretation that makes a Turner or a Michaelangelo. Yes, and this gift, too, makes a balanced interior decorator or a good dresser or designer.

Fortunate, though, is it not, that most of us, though lacking this gift of interpreting the things that are eye-pleasing and beautiful, yet possess the redeeming natural quality of appreciating beauty of form—of color harmony and of restfulness—which the gift of some artist depicts.

Then consider the range of our auditory equipment. Our cranial receiving sets can not tune in beyond certain high notes and below certain low ones, exactly as with our ordinary radio sets we cannot accommodate beyond and below certain wave lengths.

Yet in this field are again the few who are abnormally talented in their range of sound appreciation, and in their ability to compound these sounds into song or prose or poetry exactly as the artist weaves his canvas out of colors, and the sculptor his statue from clod of mud or marble.

I mentioned while dealing with sight sense, a spirit of thanksgiving for normalcy—yet I have, at times, envied the cubist his angular complex—and the colorist his sense of splash.

HEARING STRANGE VOICES

But with the sense of sound, too, while thankful for the God-given limits of tonal appreciation—I have often envied those who like the Maid of Rouen had the capacity to hear strange voices and to be moved by them—sweet Joan of France who—

> "Heard a voice that no one else could hear
> E'en tho the hillsides echoed, loud and clear."

And the bells of London Town that clanged only for Dick Whittington.

But when I recall that a guilty conscience can also spread the hearing and other sensibilities—as it did with persons of fancy, such as Lady Macbeth and the Abbot of Aberbrothoc with the bells on the Inchcape Rock, and with persons of fact such as Cain and Judas, my coefficient of thankfulness for normalcy again increases.

It is indeed an all-merciful Being that handles our dust, our doings and our destinies. Meticulously has the sound recording device in us been so arranged and developed that it registers only that span of tones acceptable to the organization that encompasses it. Had our ears been made sensitive to the noise of molecules—a day in a forest hearkening to atoms agog in growing trees would set us crazy for the rest of our lives.

THE NOISE OF MOLECULES

Listen to what Huxley, in speaking of the stirring activities going on in plant cells, says: "The wonderful noon day silence of a tropical forest is, after all, due only to the dullness of our hearing; and could our ears catch the murmur of these tiny maelstroms, as they whirl in the innumerable myriads of living cells which constitute each tree, we should be stunned, as with the roar of a big city." And whoever has heard the radio receiving set, after it catches the infinitely small electric impulses and whips them up into sounds that fill a large hall can appreciate the fullness of his statement. For sounds more silent than the farewells of ghosts can be amplified so with this new mechanism that the human ear is paralyzed with their turmoil.

But there are queer artists in tonal effects exactly as there are queer artists of form and color. For in the realm of sound interpretation too, you will find the "musical" (?) cubists and futurists —who only see the odd angles of music and fail to get the curves and concord of sweet sounds.

THE NEW PURGATORY

Earlier I refer to a pleasant brimstone purgatory. Much more modernistic and punishing would be a hell where sinners would be forced for ever and a day to look at cubist paintings and sculpture—to listen eternally to a horn with a dizzy diaphragm recording amplified jazz—nonsense set to music.

The diet would be the general run of American breakfast foods full of eternity-insuring vitamins—with bootleg rum to wash the roughage down. Then to add to the hellishness of it all the everlasting sufferers are forced to read and re-read Elmer Gantry and Clarence Darrow's Defense of Loeb and Evolution.

That *would* be Hell.

Nor are these two senses alone in their limitations, for happily the rest of our senses are likewise governed. There are odors and flavors—and touch vibrations too fine or too coarse for our limited

senses to appreciate. Thank goodness for a dignified normalcy in these directions, too.

Hearken to what Dr. Mackenzie of the medical faculty of Edinburgh has to say about our sense of smell as interpreted by Henry Tetlow, a *Ledger* columnist. He insists that the olfactory equipment of man is scarcely better than that of the amoeba. As a matter of fact I doubt that it is as highly organized as is the predatory smell sense of as low a creature as the pseudopodic vampyrell, which can apparently distinguish its special diet of algeal spirogyra by smelling it a hundred bacterial miles away.

"If in comparison with Fido, our sense of smell were as highly developed as our vision, we would in truth be sitting on top of the world. We could smell around corners. We should not have to resort to guessing at the strength of an opponent's hand.

CONSIDER THE EARS OF BUTTERFLIES

Nor is it nearly as ridiculous as it sounds. Look what the butterflies can do! You can insulate certain of them—polyphemus moth is one, and the commonest one hereabouts—with steel, glass or what you will, and its mate can smell it out. A fact which has led scientists to the interesting conclusion that whereas most odors travel by emanation, by waves of the odorous principle itself, others are transmitted in the same way that sound waves travel. Man is, presumably, insensible to these latter, just as he is to the direct contact of the sounds which are caught up in his radio and reduced to intelligible terms."

Possibly, some day, an inventor will produce a broadcasting set which will do for our sense of smell what the radio has done for our feeble sense of hearing. Think what a weapon of offense a pound of Limburger cheese might be with its emanations amplified a million fold!

But the sense of smell is in a category quite distinct from those of sight and sound, for the images it presents to the human brain are, in spite of their dual nature quite fugitive. The most that a whiff of a smell can do with us is to remind us of the last time we smelled it.

So we may register our thanks for a fundamental limitation to our sense of smell and for the fact that there is no special incentive to develop its acuity. In other words the nose knows enough.

Except again that we may be glad that to an elect few is given the ten talents in taste and smell—for out of this group we draw our

perfumers and chefs and compounders of sauces and curries and cocktails.

But to come to light and the x-Ray. The nature of light has puzzled mankind throughout history—and in many respects continues to puzzle today. Early thinking man accepted it with about the same degree of inquisitiveness as the oyster accepts the ocean. You recall that early man was this way about many things. For instance, his elaborate scheme of analysis particulated matter into only four parts—a little more generous than Caesar was with Gaul. This quartette was composed of air—earth—fire—and water, and there was a fifth ghost-like member, the quintessence, which sort of inspired and directed the aforementioned quartette.

Modern chemists have gone a great step further and matter is now elementally divided into ninety-two primitives—and some thirty thousand odd combinations of these elements are known to exist—with a million others in the offing.

The ultra-modern chemist, however, goes further yet, but returns to the simplicity, though perhaps not to the ignorance, of the ancients by affirming that matter, after all, is not composed of a choir of ninety-two—nor of the antiquated quartette—but is one grand continuous solo—with hydrogen as the single performer.

THE GREEKS WERE GREAT GUESSERS

The Greeks insisted, on a purely intuitive or hypothetical basis, that light was a corpuscular form of matter whch came from the sun and its stellar servants. And the Greeks were great guessers—and unlike the modern great guessers—the Weather Bureau for instance—quite often the guesses of the Greeks grew up to be real discoveries. Diogenes, the Greek sage in a tub, must have known, centuries before our heliotherapists, what value was in sunlight. For did he not, when visited by Alexander the Great, tell that gentleman, who would bestow a favor on him, that the greatest favor he could possibly grant, was to "get out of his light"?

You may search in many of the modern concepts—notably in the world of physics and chemistry—and you will find in the Greek period the nuclei wherefrom this current wisdom sprang.

Over 3000 years ago, Thales, the original absent-minded professor, not of Greek, but of philosophy, guessed that there was a oneness to matter—and an indestructibility that was absolute. His lodge-brother, Anaximander, agreed with him—and conceived the

existence of a fundamental unit, which he termed the *"apeiron"* and which he supposed to be "eternal in character and unlimited in extension."

Democritus, the philosopher who laughed some at his own, and a lot at others' philosophies, rechristened this primal unit of Anaximander, and called it the *atom*. The atom is still a useful term, even though the modern physicist has smashed it to pretty bits, and the Greek guess which pronounced the corpuscularity of light is returning to physical favor.

But it is a long time from the hey-day of Greece to the day when man returned to his philosophies. The civilizations that followed the athanasia of Athens were too busily engaged with greedy creeds to worry much about atoms and light. Hence the "Dark Ages."

Centuries afterward, just about the time that William Penn, "Proprietor of Pennsylvania," was drawing plans for a city of brotherly love, on the banks of his favorite fishing creek, the Delaware, a busy Englishman, Isaac Newton, discovered that light was not an elemental substance, but a composite thing capable of being divided into its component parts.

SIR ISAAC NEWTON SEES THE LIGHT

This is the same Isaac Newton whose name is familiar to every schoolboy as the apple-inspired philosopher. I do not know whether the apple, which obeyed an impulse to drop on Sir Isaac's bald spot gave him, in addition to the gravitation clue, some suggestion of the complexity of light—I would have been certain of the dual discovery had the apple been a cocoanut.

His discovery was made through the use of a glass prism, much like the kind of a glass prism which children, in hanging lamp days, were wont to peer through to get an Easter egg effect out of everything looked at.

Newton made his experiment, however, in a dark room, permitting a beam of sunlight to pass through a hole which, during Mrs. Newton's absence, he had clandestinely bored in their pale green shutter. When he passed this beam through a glass prism he found that it was broken up into a regular range of colors and that the beam was bent from its course, violet bending the most, red the least. These colors were previously known, of course, and some had names—but it had never been known what relation colors bore

to light. The conventional order in which these colors appeared in Newton's and in every similar experiment is given as violet, indigo, blue, green, yellow, orange, red.

GHOST COLORS

To this play of colors Newton gave the name "spectrum" in deference to its ghostliness, although variegated ghosts are not particularly common. Still the color effects of the spectrum are about as valuable as a ghost, and as unnatural as a shadow, for the artist cannot dip his brush in them and transfer them to his canvas. Truly they are spectral hues.

Of course, it must not be construed that Newton was the sole latter-day pioneer in the study of light, for certain phenomena and laws of light had been well known some years before his time, Snell in 1621 and Descartes, a little later, had worked out and published their studies on light refraction—but they had no idea, in spite of rainbows, that, light, like Joseph's coat, is a mixture of many colors.

Newton, scientist that he was, did not stop with this one experiment, in spite of the fact that he was busy mapping the solar system, explaining the tides, building the first reflecting telescope and suggesting problems for future crops of philosophers to puzzle over.

Not satisfied to tear light into its colored fractions he attempted further to subdivide these colors. For instance, he passed portions of the spectrum, found by the first prism, through another prism, but try as he would he could not make the green give other than green, nor red other than red.

Furthermore, not convinced by analysis alone, he turned to synthesis and proved that the colors of the spectrum could be reccombined to form white light.

"Nature and Nature's laws lay hid in night,
God said: 'Let Newton be' and all was light."

That is how Pope epitomized the doings of the great author of "Principia," that work of Newton, which Halley, too, eulogized "So near the gods, man cannot nearer go."

THE CHANGELESS SKY-HIGH SPECTRUM

For centuries the greatest spectrum of all, the rainbow, had been accepted, through the belief of ancient Hebrews, merely as a symbol of God's bow, forever hung high on clouds, an earnest of His promise, never again to punish with flood and hurricane His sinning Israelites. Indeed

Jehovah himself is quoted as having said: "And it shall come to pass, when I bring a cloud over the earth that the bow shall be seen in the cloud, and I will remember my Covenant which is between me and you and every living creature of all flesh, and the waters shall no more become a flood to destroy all flesh."

Recent experiences in Vermont and with the Mississippi rather prove the local fallibility of rainbows.

And so even Newton himself overlooked the greatest spectrum of all and turned to pigmy rainbow effects plastered on his kitchen wall. What Newton discovered after all was only the visible spectrum, in other words, only such colors as the human eye is organized to pass into consciousness for those who possess the faculty of sight.

But after Newton came others who amplified and developed his studies in several directions, for the discovery of the spectrum was only an invitation to further exploration. Light since then has taken on a great significance—and the end of the road is still far off. Today more than ever, are we aware of the close contacts between life and light and it is not unwise to prophesy that we are on the borderline of tremendous discoveries in this field.

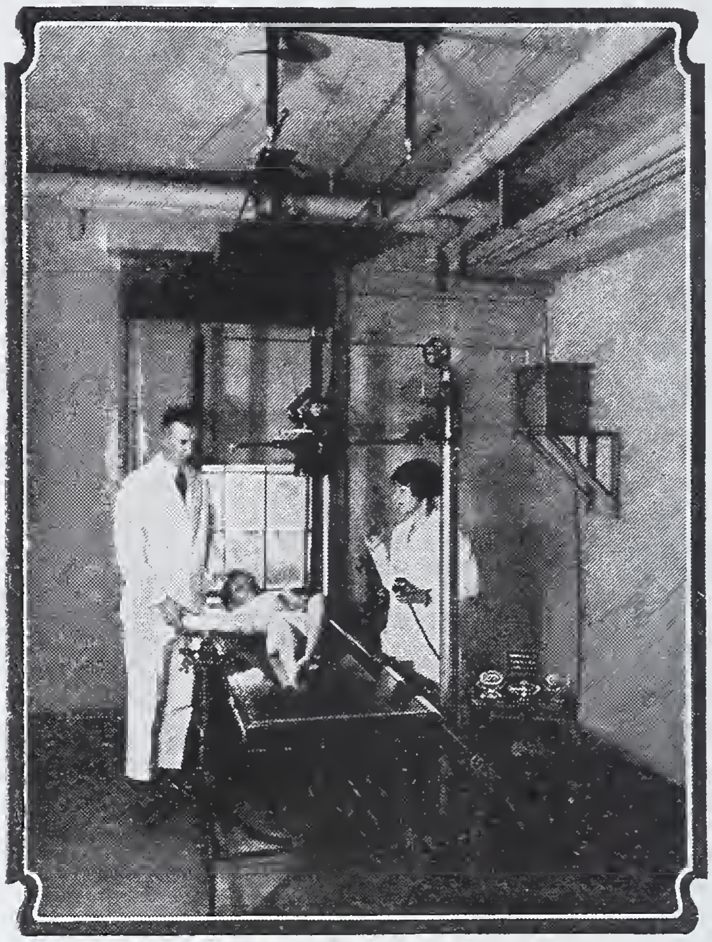
Since Newton's day science has demonstrated conclusively that light is infinitely more than ever Newton conceived it to be. That great man and many who followed him were much handicapped by a meager supply of instruments and power wherewith to augment their limited sense faculties, and such handicaps are more than ever appreciated when we tell you that the greatest effects of light after all are such as cannot be studied with eye unaided nor separated without strenuous methods and concentration.

Listen to this quotation from one of Dean LaWall's former lectures and understand what a tremendous advantage modern physicists have over such as Newton and Tollaston and other early workers in the realm of light.

TOOLS OF MODERN PHYSICS

"Testing machines have been perfected with a compressing force of millions of pounds per square foot and yet so delicate in their adjustment that the slight pressure necessary to crack an egg shell can be measured by the same machine. Measuring devices are available for accurately determining the velocity of light in spite of its mania for speed. An instrument used by astronomers for measuring angular magnitude

is capable of detecting an arc of one inch subtending a radius of 100 miles. Electric power has been developed so intensely that hundreds of thousands of volts can be marshalled and directed to do man's bidding. A thermometer for making temperature measurements is so refined in its adjustment that the heat from the flame of a match held many feet away can be recorded. Balances are in use that are so sensitive as to detect the 1/30 millionth of an ounce, and when we consider the spectroscope, which is four million times as sensitive as the finest balance, and the electroscope, which is a



The x-Ray Laboratory

million times more sensitive than the spectroscope, we seem to be nearing the limit of human possibilities in the direction of physical measurements. All of these instruments and others almost equally amazing have been summoned to aid in unfathoming the mysteries of physics and chemistry."

While the word light truly but describes that kind of ethereal radiation which is capable of affecting the eye, yet in a broader way there are fractions of light, below the visible red and beyond the visible violet, which are infinitely more important than such visible effects as are encompassed by the spectrum.

THE x-RAYS IN NATURE

Here dwell the infra-red rays—the radio transmission waves, the ultra-violet rays and the x-Rays—and a great many other rays.

And someone asks the question: "Are x-Rays and other like rays in Nature, outside of those generated in the laboratory." The answer, of course, is Yes!

Indeed, they play a most prominent part in Nature's activities—at present, not at all understood. Yet we do know of their busy presence in atmospheric electricity, their temporary imprisonment in the radio-active elements, and their very definite share in the light given out by sun and stars and in concurrent life processes.

Do you wonder that it took so long to find out some of these things about light when it is known now to travel over ten million miles a minute, or accurately 186,000 miles a second? At this rate it takes less than ten minutes for it to come to us from the sun, which is ninety-three million miles from the corner of Forty-third Street and Kingsessing Avenue in Philadelphia.

Of course, there are myriads of other suns from where it might come to us. Unfortunately, they are so far away that their light takes many years to reach us.

And so we turn now, after what may have been a rather involved and long-winded introduction to the realm of the x-Ray, which is on the nether side of the visible spectrum. Some time after Newton's day Karl Wilhelm Scheele, a young apothecary, noted that there were influences beyond the visible end of the spectrum which possessed definite chemical properties. He proved this beyond doubt by demonstrating that silver chloride could be reduced by these influences into elemental silver.

After him came Ritter and Young who early in the nineteenth century discovered the ultra-violet rays. In an article entitled "Light and Health," Dr. Mayo of Rochester, attaches a great importance to these short rays:

> "Certain wave-lengths of ultra-violet rays are most important in stimulating the chlorophyl (which is the green of plant life), the hemoglobin of blood-cells (which, in thin layers, are also green), and the photo-sensitive plate. The ultra-violet is the most stimulating and is held by the tissues of the skin while shorter and longer waves at both ends of radiant energy pass through or are absorbed by the body. Thus red glass holds back all but the red waves of the light or visible

spectrum and passes a considerable quantity of heat waves. Ultra-violet causes the cells of the skin to protect their nuclei rapidly by screening with melanin, or the so-called tan of sunburn. Such rays lower blood-pressure from 7 to 10 per cent., somewhat increase the oxygen of the blood and blood calcium, the activity of endocrine glands, and the storage of iodine by the thyroid. This is of great importance as the blood carries the same fourteen primary elements that good soil does for plant life. The ultra-violet increases vitamin A; in fact can develop it in linseed oil exposed to the ray. Cod-liver oil has a large amount of this vitamin. Thus the violet ray of the sun prevents and cures rickets, which is so prevalent among the children of Scotland with its fog and the clouds and smoky air, as it is approximately only for one-half year that they have much chance with old Doctor Sunshine.

"Fortunately man's ingenuity has developed the quartz glass (or fused quartz) which permits the ultra-violet ray to pass. Celluloid and paraffined gauze are also somewhat permeable to it while common window-glass cuts out most of it. Thus the mercury-vapor quartz-lamp, or arc light with carbons combined with nickel, emits a large amount of ultra-violet which can be used in the treatment of chronic diseases, especially tuberculosis of the lungs and joints. The greatest effect of ultra-violet from sunlight is obtained at midday as the rays pass through the thinnest layer of air over the earth. The long slanting rays of morning and afternoon are largely screened by the air, especially because of the average half-inch layer of water diffused in hydroscopic form throughout the air. Thus high mountain altitudes are used in order that such sun treatments shall be most effective, although ultra-violet treatments are of value for shorter periods in any place, and artificial ultra-violet light can be created where nature gives little or no aid with sunlight."

Herschel in 1800 caught the infra-red rays hiding on the other side of the spectrum. Their heat-producing qualities were definitely established through the agency of a very sensitive thermometer. He proved that, beyond the violet rays of the spectrum were the rays that manifested the least heat and that beyond the red was a zone as yet uncharted, but which carried a definite amount of energy as heat.

These rays have not been extensively studied. They pass through many substances such as glass, mica, etc., about as readily as a cootie might pass through our City Hall gates. Yet certain substances, like quinine hold them back, a fact which has been applied

in making sunburn creams which are supposed to prevent the intense effects of seashore sunburn.

Sunfast straw hats are also said to utilize this principle.

During the World War infra-red ray photography was largely used by aviators, by virtue of a peculiar property which they had of differentiating the natural green of foliage from the green colors of camouflaged defences. For this purpose certain filters which excluded all but the infra-red wave lengths were utilized. These rays are being intensively studied at present with a view of their therapeutic applications.

A great development in the field of light came through Roemer's appreciation of the fact that light had a finite velocity and was undulatory, that is, it travelled in the form of waves.

The various colors of the spectrum and the influences outside of the spectrum are now known to be simply radiations that differ only in their wave lengths. They do not differ in any other essential particular. Through the whole range of telegraphic waves, which may be a mile or more long to x-Rays, of which the wave length is actually smaller than the diameter of atoms, and capable of expression only in terms of billionths of an inch—they travel at precisely the same speed—the only speed at which the ether is able to transmit energy, and are all subject to the same laws of interference, of refraction, reflection, etc.

A HOMELY ANALOGY

The only difference in these several light forces is as stated previously—in the length of their waves and of course in their frequencies. A rather homely analogy to use in this connection is to borrow a leaf from Bud Fisher's book or rather his carbon mannikins, Mutt and Jeff. Mutt, you will recall, is the narrow individual with the narrower and longer legs; Jeff being the compressed one, with short legs and an insufferable conceit. Now then, assuming that the pair harmonize long enough to cross a mile-long bridge starting together and ending together. Their traveling distance and time will have been exactly the same, and their velocities identical. But it takes no vivid imagination to know that Jeff's little legs must have vibrated and oscillated twice as fast as Mutt's long extremities.

They covered the same distance in the same time, at the same speed simply because Jeff's frequencies or knee jerks equalized Mutt's wave lengths or steps.

So it is with the rays of various kinds—their velocity is constant, the only difference comes in the wave lengths or steps, and a consequent difference in frequencies.

Pons Asinorum—Q. E. D.

In order to standardize matters, measurements of wave length have been established. The unit of measurement has been fixed by convention (International Union of Solar Research) and is called the Angstrom (A.).

Anders Jonas Angstrom was a Swedish physicist (1814-1874). He wrote *"Reserches sur la Spectre Solaire,"* 1868. The unit there, considered, in terms of the metric system, is equivalent to a wave length of one ten millionth of a millimeter. Measured in inches, an Angstrom unit is equivalent to one two-hundred-and-fifty-four millionths of an inch.

One meter	*equals* one thousand millimeters.
One millimeter	*equals* one thousand microns.
One micron	*equals* one thousand millimicrons.
One millimicron	*equals* ten Angstrom units.

By means of these units the fractions of light are put on a perfectly arithmetical basis. Thus the color of light in terms of its wave lengths in Angstrom units may be given as follows:

Invisible:

Infra-red region	Over-7700A

Visible:

Red	7700-6200A
Orange	6200-5900A
Yellow	5900-5600A
Yellow-green region	5600-5300A

Visible:

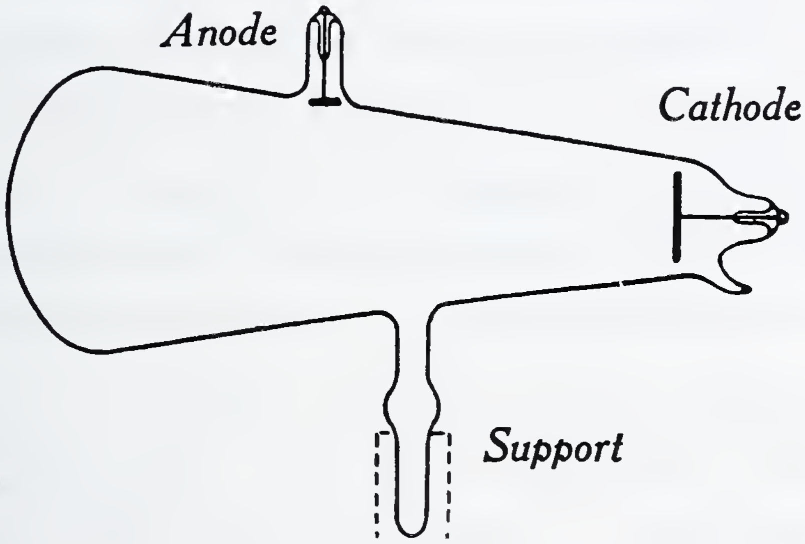
Green region	5300-5000A
Blue-green region	5000-4700A
Blue region	4700-4300A
Violet region	4300-3900A

Invisible:

Ultra violet	3900-2000A
x-Ray, etc.	Below 2000A

RÖNTGEN

In 1895 Professor Wilhelm Konrad Röntgen of Würzberg, Bavaria, discovered almost accidentally the x-Ray, as we call it here, or Röntgen ray, as Europe calls it. He was experimenting with a device known as a Crookes' tube, which grew out of a toy vacuum tube devised by Geissler of Bonn in 1857. Sir William Crookes (1832-1919) had noted that the negative pole of a vacuum tube gave off cathode rays if excited by a high frequency source of electrical current, and that the intensity of this ray production increased as the rarefaction of air increased.



Type of Tube with which Röntgen discovered the x-Ray

TRAILING THE x-RAY

Röntgen was indulging in the then scientific pastime of trailing rays—and having wrapped up one of these vacuum tubes in some black paper, he was amazed to find, that, after he turned on the switch, a fluorescent screen which he had casually placed on a nearby table shone out brightly. The light-tight cover precluded any possibility of the effect having been due to ordinary ultra-violet light, and Röntgen was convinced that some strange radiation was stealing its way from the tube. When he interposed his fingers in front of the tube he saw that they cast uneven shadows on the screen and in this way he tracked back the unknown or x-Rays to their lair.

That proved to be the spot where the cathode rays hit the glass wall of the tube. Further investigation proved that these rays are produced wherever cathode rays encounter matter. *Today we know that x-Rays are caused when individual electrons, travelling at a high speed in a vacuum, encounter the obstruction of a target.* The modern physicist will tell you too, how small these electrons are, by asking you to recall that an atom is the smallest particle imaginable,

and then confounds you by telling that an electron bears the same relation to an atom that a fly does to a cathedral, or a flea to a Zeppelin.

But to Röntgen the fascinating feature of the new rays was their unusual ability to crash through many substances with which ordinary light had no chance of penetration. He had noted when he held his fingers in front of the fluorescent screen that his flesh being less dense than his bones, the latter stood out dark as compared with the shadow of his flesh on the screen.

He at once grasped the tremendous possibilities of his discovery and—gave it away to the world. To a little group of wide-eyed surgeons gathered at a medical meeting house in his old home town, Würzberg, Röntgen communicated his epoch-making find.

Röntgen was not a physician—nor a surgeon, yet he freely gave to that profession for humanity's sake, a marvelous diagnostic aid which has made certain aspects of surgery more certain than ever before.

How differently did the physician Ehrlich behave with his equally marvelous discovery of salvarsan, that specific remedy for the unspeakable disease. "Covered by letters patent"—that was the story of salvarsan—and Ehrlich lived long to capitalize, with his boon, the sufferings of victims of that dread malady. But Röntgen was built of different stuff.

INVENTION RARELY COMES FULL-BLOOM

It is rather unfair to give Röntgen all the credit for the discovery and practical application of the x-Ray. Indeed such invention is never a one-man job. Who has ever watched beneath the tell-tale acreage of lenses well assembled, the growth of a perfect crystal, but cannot draw from it a parallel to the consummation of any great discovery, such as this discovery of the x-Ray? Indeed the progress of a crystal in its growth from nuclear source, out of the depths of murky fluid, is always one of slow but dead-sure progress. Tiny particles, builders of every crystal, dance about in Brownian ecstacy, and dart in all directions, searching for their nuclear leader. Finding it they come to rest beneath its ramparts. And from all directions they draw their cohorts to the coalescence, and only the proven pure can join their congregation.

Atom upon atom, particle upon particle, and sheath upon sheath, the crystal is built, gradual, orderly and certain. Finally

facet, axis and edge, definite in every detail, announce with no mistake the form of a perfect crystal. And the dross, the foreign and colloid things are left behind in the fluid—only the actual, belonging things find room in the mass of the crystal. This finished crystal, so the physicist states, is now the large scale, accurate picture of each of its little atoms. Such, we say, is the tale of every invention in every field of endeavor. Invention never comes full blown, as Jove begat Minerva, but slowly like the gathering home of atoms to a naive, attractive nucleus.

And before and after Röntgen have come many, many workers who shared in bringing the x-Ray and other similar forces into their present field of usefulness.

To effect his discovery it is interesting to note that Professor Röntgen was particularly indebted to previous inventions such as:

> The pear-shaped vacuum tube devised by Geissler of Bonn, and improved by Crookes and Hittdorf and others.
>
> The air-pump, as first made by Otto Von-Guericke in 1650, for creating a vacuum.
>
> A high tension electric current, as first produced by Faraday in 1838, to send through this vacuum.
>
> A fluorescent screen, consisting of a deposit of barium platino-cyanide crystals on cardboard, used by physicists in previous investigations of ultra-violet light, having found that these crystals had the property of giving off visible light while in the path of an ultra-violet beam.

But beyond all, posterity owes Röntgen everlasting acclaim for the strength of mentality to convert an accident into an observation that showed the way to marvelous possibilities.

I am unable to restrain myself from quoting the result of an interview with Professor Röntgen which Sir James Mackenzie Davidson, an eminent English scientist describes.

> "I presented myself about 11 a. m., and was shown into a laboratory which contained a coil and a small cylindrical-shaped x-Ray tube. Professor Röntgen, a tall man with dark bushy hair, a long beard, and very kindly and expressive eyes, received me cordially. He could not speak much English; I was still worse at German. However, by means of English and some Latin we made ourselves intelligible to one another.

"I asked some blunt questions as follows:

"Q. 'What were you doing with the Hittdorf tube when you made the discovery of the x-Rays?'

"A. 'I was looking for invisible rays.'

"Q. 'What made you use a barium platino-cyanide screen?'

"A. 'In Germany we use it to reveal the invisible rays of the spectrum and I thought it a suitable substance to use to detect any invisible rays a tube might give off.'

"He then detailed how he made the discovery. He said he had covered up the Hittdorf tube with black paper so as to exclude all light, and had the screen (which was simply a piece of cardboard with some crystals of barium platino-cyanide deposited on it) lying on the table 3 or 4 metres from where the covered tube was situated, ready to be used. He excited the tube to ascertain if all light was excluded. This was so, but to his intense surprise he found the distant screen shining brightly!

"I asked him, 'What did you think?' He said very simply, 'I did not think, I investigated.'

"Incidentally, he told me how he had taken a photograph through a pine door which separated two of his laboratories. On developing the negative, he found a white band across it, which, he ascertained, corresponded to the beading on one of the door panels. He stripped the beading off, and found the band of shadow was due not to the increased thickness of wood but to the plumbum (white lead, really) the doormaker had employed in attaching the strip of wood.

THE HISTORIC SCREEN

"He seemed amused at my remonstrating with him about keeping the 'screen' lying about in his laboratory. I told him it was a 'historical screen,' and should be preserved in a glass case! I hope he has carried out this suggestion. For the sudden shining of that 'screen' undoubtedly led to one of the greatest discoveries in modern times."

THE FIRST PUBLIC SHOWING OF THE x-RAY

Immediately after Röntgen's discovery, physical scientists everywhere, attacked the problem of improving and elaborating the rather crude vacuum tube used by the discoverer. The arts and the industries, too, turned to the business of applying the new agency in some practical way. The whole world was agog with x-Rayitis, and the first generators and devices were investigated with so much meticulosity,

were gossiped about with so little veracity, were newspapered with so much generosity, as is comparable only to the recent success which Henry Ford displayed in steering his new Bouncing Bet right into the heart of every American establishment.

There are some here who recall vividly the curious crowds at the first display of bone-exposing x-Ray apparatus out in the Philadelphia Commercial Museum, where but two or three decades later it was Henry Ford's magnanimity that permitted similar crowds to gaze in rapture at his glorified bone-wrenching apparatus. *Sic transit!*

Through quick successive stages the x-Ray passed in point of evolution and development until the present armamentarium of the roentgenologist is as incomparable with Röntgen's original apparatus as one of the new electric superheterodyne radios would be with that toy of a radio compounded from oatmeal boxes, bell wire, a piece of galena crystal and the cat's moustache, which gave us the original thrill of picking music through the rain drops.

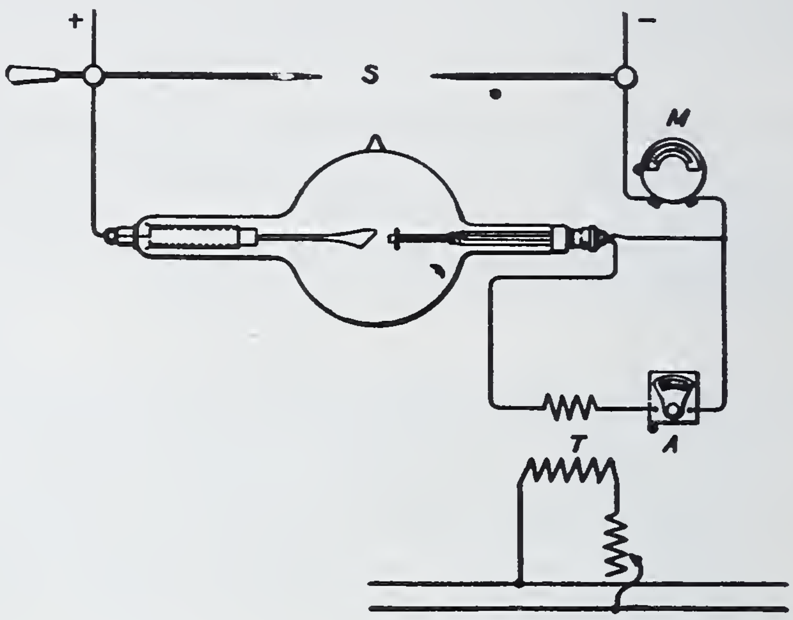
THE FIRST DEVELOPMENT: THE COOLIDGE TUBE

Three outstanding developments occur to us at present. They are firstly the *perfected vacuum tubes,* notably the *Coolidge tube,* which operate with more constancy than the older forms—which so commonly developed cranky streaks.

Dr. Coolidge, who is associated with the General Electric Company, devised a tube

> "where the cathode consisted of glowing tungsten and the vacuum in the tube was made as perfect as possible. Such a tube can be operated continuously and still show constant characteristics. Referring to the diagram shown herewith, the cathode of the Coolidge tube is a small spiral of tungsten wire so arranged that it can be electrically heated by a small transformer.
>
> "A rheostat allows the filament current to be regulated to give the filament temperature desired. The filament current is independent of the high voltage connections to the x-Ray transformer proper.
>
> "When the filament is heated there is an emission of electrons which, when the high voltage current from the x-Ray machine is placed across the tube terminals, serve as a medium for carrying the x-Ray current through the tube, *i. e.,* from cathode to anode."

The speed at which these electrons travel across to the anode is determined by the amount of voltage impressed. If 60,000 volts is impressed the electrons will travel at an approximate speed of 82,000 miles per second, and the resulting tremendous impact on the tungsten target in the anode produces the still more rapid x-Rays. The penetrating power of these x-Rays corresponds to the speed of these electrons at impact, and this speed may be varied at will by the amount of voltage impressed across the tube terminals. Those who are familiar with the electron theory of the modern radio tube will readily understand the principles of operation of the Coolidge tube.



The Coolidge Tube

THE SECOND DEVELOPMENT: ELECTRICAL DISCOVERIES

The second development was in connection with the new *electrical discoveries whereby increased voltage has been made possible.* Even the smaller x-Ray laboratories are now capable of building up voltages well over 200,000, a definite essential where deep-ray therapy is being practised.

THE THIRD DEVELOPMENT: IMPERVIOUS MEDIA

Thirdly, came the *devices whereby, for diagnostic purposes, the ray was made exceedingly more valuable.* Fleshy tissue is pervious to the ex-Ray, and in consequence internal tumors and other formations, being fleshy in nature, show little or no shadows on the plate.

For instance a growth inside the stomach could not be readily demonstrated by the x-Ray picture alone, and the only satisfaction to curiosity came by way of a good surgeon with a collection

of sharp knives. But the idea struck someone that if the inside of the gastric cavity was kalsomined with some harmless material, impervious to the ray, a good outline picture could be secured. Accordingly, so was it done.

Bismuth subnitrate,* barium sulphate and similar innocuous and ray-obstructing chemicals are poured down the gastronomic chute of the candidate, who is in due time placed on the grill and pictured.

Radiograph taken with barium meal in the intestinal tract

Deformities in internal organ outlines are clearly delineated in this way—and the procedure has been of intense value as an aid to diagnosis.

The idea of Ehrlich's selective affinities has also been used in this way, and the gall gladder and duct, heretofore shy to the photographer are made bold in outline by pouring into the system a chemical which travels through the body until it finds its friend the

*Hereabouts the late Martin Wilbert, Apothecary to the German (Lankenau) Hospital, is credited with introducing such compounds to x-Ray practice.

gall bladder, with which it stays long enough to make it impervious to x-Ray and to cast its shadow on the plate.

Nowadays the surgeon does not have to take the gall bladder out on general principles or for lack of them—he x-Ray-inquires first, and having found through that medium that the bitter bladder is pathologic, he then proceeds to sharpen his knives and rip saws.

So that at least a part of this presentation will have a semblance of regularity I choose to run in at this point an orderly, summarized presentation of the uses of the x-Ray in its several fields.

IN MEDICINE

It is not difficult to conceive what consternation would reign in medical ranks should the physician and dentist and surgeon be suddenly deprived of the use of the x-Ray. There is practically no region of the body that is not subject to a searching examination for the detection of disease or injury at some time or another. Many cases where the treatment of some conditions would have proved complicated and the outcome very much in doubt, had not x-Ray been available, are now easy to diagnose and sometimes to treat.

One of the very common uses of the x-Ray in the hands of the physician and surgeon is in diagnosis and treatment of fracture cases. When a broken bone is suspected, off goes the patient to the invisible ray artist, who exercises his judgment in the kind of a ray intensity needed to depict the particular bone whose fracture is suspected. This simple picture-taking operation is not unlike an ordinary portrait taking, except that one need not look particularly pretty nor feel correspondingly uncomfortable with it.

Anyone at all familiar with ordinary camera photography will readily understand this step in the procedure. The photographic film, in a suitable light-tight holder, is placed under the injured part of the patient, while the x-Ray tube is focussed above. The x-Rays emanating from the tube penetrate the part of the body under observation, and finally reach the emulsion of the film, recording the shadows and various densities much the same as ordinary light acts on the film in a camera.

With the radiograph before him, showing the exact nature of the fracture, the physician can now intelligently and effectively set the fracture. After placing the limb in a cast he again resorts to the

x-Ray as a means of checking up, to determine whether correct setting of the fracture has been accomplished. The result is that in the treatment of most fractures in present-day practice, the x-Ray insures more or less against impaired functions of the injured parts. such as our fathers so often suffered simply because there was nothing wherewith to check up the "bonesetter."

Where every head is a bone-head

THE INQUISITIVE RAY

Fluoroscopy is another form of diagnosis with x-Rays. This involves the use of a fluorescent screen, consisting of a cardboard surface treated with chemicals which fluoresce, *i. e.,* give off visible light, when exposed to the action of the rays. With the patient placed between the tube and the fluorescent screen, the rays pass through the body and act upon the chemicals on the screen, causing them to cast ominous shadows on the screen.

In this way it is possible to interpret heart action, and lung structure, to study the track of food through the stomach and through the convolutions of the intestine, and so to gain intimate knowledge of digestive functioning.

Through the use of opaque materials it is possible to study the structure of the kidneys and ureters. Many other abnormalities such as tuberculosis, cancer, and the various tumors, including carcinoma of the breast can be revealed with the x-Ray.

A few reproductions of Dental Radiographs. Courtesy of Dr. C. O. Simpson, St. Louis.

(Read left to right)

1. The development of the permanent teeth to replace the baby teeth.

2. The abnormal development of a tooth bud which has prevented the eruption of a normal tooth.

3. An impacted third molar which has destroyed the root of the second molar. Also an abscessed first molar under a crown.

4. Extensive destruction of the bone from a tooth without metallic fillings.

5. A cyst which has destroyed the bone around a tooth and the outer plate of the jaw.

6. Advanced destruction of the bone around the teeth from pyorrhœa alveolaris.

Even the appendix can be routed out of its hiding place by this inquisitive ray—that is, providing the surgeon has not been there first.

The same means are used by the physician to locate or detect foreign bodies. Most everyone has seen at some time or other, x-Ray reproductions showing pins, safetypins, nails, coins, buttons, hair pins, pipe stems, tooth plates and other spare parts lodged in the trachea or in parts of the alimentary tract. These foreign bodies which are accidentally swallowed, cause a great deal of alarm. With

Radiograph of an Egyptian child mummy in a wooden casket. (This child lived about 3000 years ago.)

the x-Ray, however, the surgeon learns whether an immediate operation is necessary. If not, he can watch the progress of the foreign body from hour to hour, sometimes from day to day, and in a great number of these cases sees the final expulsion of the article without surgical intervention.

For even a surgeon is glad, on occasion, to avoid an unnecessary carving.

In dentistry it is invaluable in charting the hidden geography of our jaws and sullen, silent abscesses are demonstrated through means of the x-Ray. The universal pastime of tracking a focal infection to its hiding place in tonsil or toenail or tooth has found the x-Ray a most invaluable pus-hound.

Deep ray therapy is a fairly new development of x-Ray application. This form of treatment began a few years ago in handling certain forms of skin diseases with marked success. This was only superficial x-Ray therapy.

Since the advent of the 200,000+-volt Coolidge tube in 1921, however, interest in the treatment of deep-seated malignant diseases with x-Rays has been greatly stimulated, and while specialists prefer to wait over a period of years before stating definitely the degree of success realized, they are much encouraged with the results attained thus far in the treatment of cancer, that much-dreaded disease so widely prevalent today, and which has baffled medical scientists for ages.

The old concept of curing like with like may be playing its silent game in this connection, too, for cancer is considered by some to be a disease due to a vitamin deficiency or excess. And since vitamines are stated to be "Compressed light" the use of ray agencies, such as radium emanations and deep x-Ray in the treatment of this alleged vitamin disease, is quite in line with the Hahnemannian concept.

THE x-RAY IN INDUSTRY

Röntgen and others foresaw the value of the x-Ray in industry especially insofar as the study of metal structures is concerned. Yet the ray, here, too, was not of much value until the development of the higher power Coolidge tube, capable of handling 200,000 + volts. As pointed out elsewhere the more dense the material, *i. e.,* as the atomic weight increases, the more powerful must the x-Ray be to penetrate it. And as the voltage is increased in the x-Ray tube, the resulting radiation is increased in its power to penetrate a given substance.

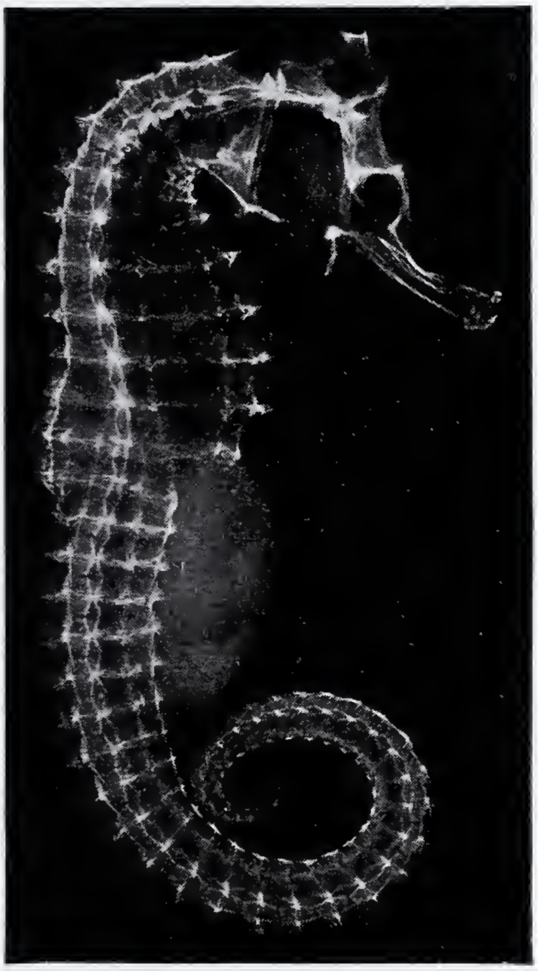
Dr. H. H. Lester, Research Physicist, at Watertown Arsenal, Watertown, Mass., in an article "X-ray Tests Applied to the Problems of the Steel Foundries," presents the following abstract:

> "X-ray tests with collateral analyses indicate that defects in steel castings fall into a relatively few classes traceable to definite and simple causes, most or all of which are removable. When defects are detected by X-ray examination and corrected by changing casting technique, they tend to stay corrected. It is possible by this method to eliminate from 75 to 90 per cent. of the major defects to steel castings.
>
> "Metal sections up to 3 inches in thickness may be examined. Where the value of the product warrants it, x-Rays may be used to test each individual casting. In other cases casting technique may be developed that will produce sound castings."

With its use hidden cracks in metal structures, and uneven distribution of components in an alloy are readily detected.

During the war the manufacture of explosives found great use for this great penetrating force. The correct filling of shells and liquid grenades, the interior study of detonators, igniters, etc., the checking of packing box contents, were made possible through its agency.

The study of wood structure as exemplified in airplane propeller examination, the study of optical glass, of hidden metal structures, were a few other war-time applications of the x-Ray.



x-Ray study of a Seahorse

Among other miscellaneous uses I can but briefly refer to such as the examination of golf balls to ascertain symmetry of core, of oysters for pearls, of metal mill particles in ground drugs, in the sorting of antiquated from fresh hen's eggs and many other similar uses.

Then one should mention the ingenious use made of the x-Ray by footwear dealers who permit customers to convince themselves by visual evidence that it is a feat to fit feet.

The archeologist or official grave robber finds it very handy where a coffin or a sarchophagus with its quiet content need not be disturbed, and yet have its secrets revealed.

Old masters by way of paintings can also be authenticated in this wise, modern paints and sizings showing great difference in opacity over those of the ancients.

THE DANGERS OF THE x-RAY

In past years the newspapers have recorded the deaths of a number of pioneer roentgenologists who were martyrs to x-Ray science, through having received the so-called x-Ray burns which resulted fatally.

Diaphanous Daffodils

These x-Ray burns had been inflicted years ago before science had determined the danger of unduly exposing the body to the rays without due precaution as regards protective devices. In other words, these pioneers in their intensive experimental work had unknowingly harmed themselves, some of the serious effects not being noticed for some years following exposure to the rays.

Fortunately, that day has passed, for modern equipment and modern methods have every provision for the protection of both operator and patient against the harmful or secondary rays, so that in the present day x-Ray burns can occur only through gross negligence or ignorance. Consequently, when we submit ourselves for x-Ray examination to a competent roentgenologist, we need feel no

fear of harm from the comparatively small amount of primary rays required in the production of a radiograph, or in the usual fluoroscopic examination.

In other words, x-Ray treatment has been in this day made "Safe for Democracy"—and for other denominations, too. Except—if we believe one of the most recent sensations in science. According to *Science Service,* x-Ray treatments of certain kinds, particularly of

"'Tis a feat to fit feet"—to suit the x-Ray

the "deep therapy" type, may be laying a terrible toll on the descendants of patients now receiving them. Defects and malformations *may* be visited upon their children far beyond the scriptural third and fourth generations; if man reacts to them as flies and rats do.

THE x-RAY AND HEREDITY

Yet the same kind of x-Ray treatments can speed up a hundred-fold the rate of the controlled evolutionary processes used by breeders to produce improved kinds of animals and plants.

This sensational paradox of science may be looked to for hitherto little suspected perils in the field of medicine and for revolutionary effects in agriculture, if the findings made by Prof. H. J. Muller,* of the University of Texas, on tiny fruit flies, the kind that buzz around grapes and peaches, hold true for other living things. These flies were chosen because of their promptness in attaining to maturity. Man takes twenty-one years, the fruit fly twenty-one days.

It has been proved in his experiments that in the germ-cells of the flies, x-Rays affect the little particles responsible for heredity (chromophores or gene aggregations) in much the same way as a cannon ball fired at a pile of pills would affect the pills. The hereditary particles become permanently transformed in all sorts of unexpected ways and the sudden changes known as "mutations" are produced in them.

Not all of them mutate at once, Prof. Muller explains, but here one, there another, they change in quite a random fashion. Sometimes also they are dislodged into new arrangements. Since these hereditary particles, which are known as "genes," and contained in the cell chromosomes, are handed down from parent to offspring, and determine the characteristics of the next and later generations, all kinds of new traits are likely to arise among a group of offspring or grand-offspring from parents that were treated with x-Rays. These new traits are permanent, as they are inherited by succeeding generations.

x-RAY SPEEDS UP EVOLUTION

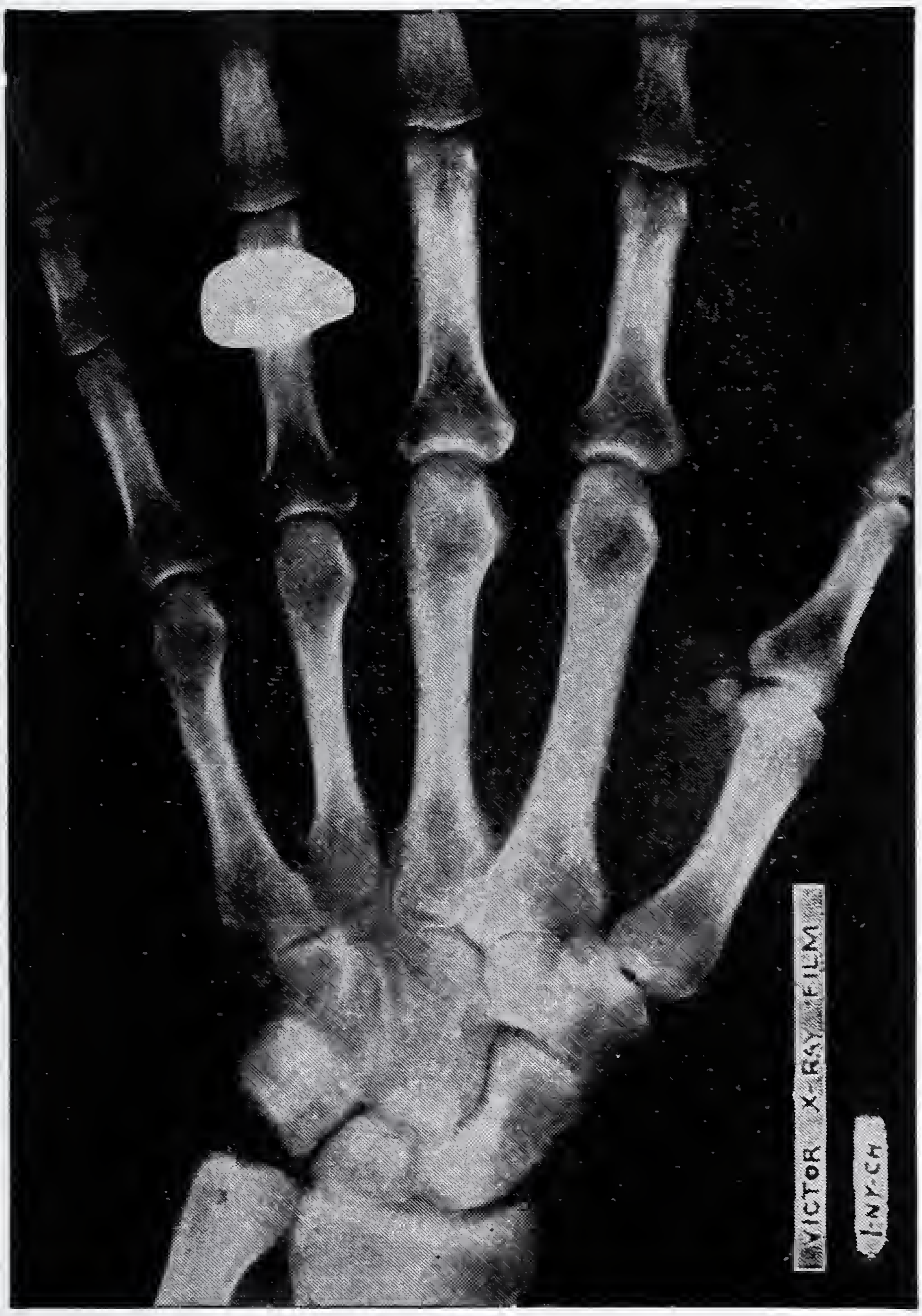
It has long been known that such mutations occasionally happen without x-Ray treatment, and so give a chance for the breeder to improve his stock, by breeding from animals that have desirable mutations. In the same way in nature, the "survival of the fittest" mutations is thought to have brought about evolution. But the mutations that happen without x-Ray treatment are exceedingly rare and it has never previously been found possible to make them occur oftener. That is why animal and plant improvement has been so slow, and why it has been necessary to raise countless thousands of ordinary individuals for each advantageous mutation that has turned up.

*Dr. Muller's paper was judged to be the most notable presentation made at the meeting and won the $1000 award.

x-RAY: THE BURBANK BEYOND THE SPECTRUM

Now, if mutations can be produced at will, all this will be changed, and the production of new plant and animal varieties will go as far forward in ten years as it formerly did in a century.

But mutations, whether produced by nature or by x-Rays, are bad oftener than they are good. The plant or animal breeder simply

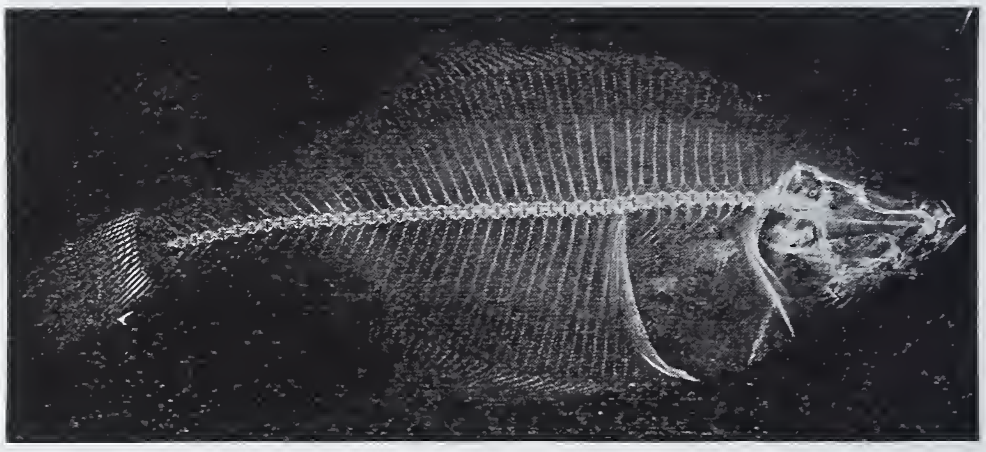


The first Radiograph ever transmitted by telephone wire

throws away a hundred bad new varieties and keeps one good one. It is here that Dr. Muller sounds his warning as regards human beings. We do not make a habit of throwing away undesirable babies, and anything that might tend to produce a crop of unfortunate human freaks or cripples should be used on human beings with

extreme caution. *This does not mean,* he emphasizes, *that all x-Ray examinations or treatments are dangerous, but only those that expose the reproductive organs to prolonged or intense doses of the rays.*

In particular, x-Ray treatments applied for the purpose of deliberately producing temporary sterility are frowned upon. Five years ago, at the London meeting of the Birth Control Congress, Dr. C. C. Little, then of the Department of Genetics of the Carnegie Institution of Washington and now president of the University of Michigan, characterized the practice as "little short of a calamity." At that time Dr. Little described experiments of his own on rats which had been subjected to this treatment. Young born to them



The inedible framework of a fish as the x-Ray depicts it

subsequently appeared to be normal, but the third and following generations were marred by the frequent occurrence of repulsive physical defects and monstrosities.

Important as the possible human and practical consequences of his study may be, Dr. Muller states that the work so far constitutes only a beginning of the possibilities that lie along this line.

THE x-RAY IN THE REALM OF PHYSICS Through the agency of the x-Ray, especially in connection with the spectroscope, physicists have been able to study the internal structure of the atom. It was through its agency, too, that Becquerel made the original investigations that spurred the Curies on to their discovery of radium and its contained forces.

Since the advent of x-Ray crystallography, too, has undergone a vast development. Indeed, the revelations of this ray and its

kindred, in the realm of physics, is a subject too ramified for us to do else than mention it.

I want to conclude this rather disorganized address with a few quotations from addresses made at a recent meeting of the American Association for the Advancement of Science. This meeting gathered, queerly enough, yet possibly not without malice aforethought, in the hot-bed of sciosophy—the habitat of hokum, namely Tennessee. These abstracts show the significant part which the x-Ray —this very modern tool of scientific research—plays in the new order of things. The quotations are again from *Science Service:*

NASHVILLE, TENN., DEC. 29.—X-Rays are playing a highly important part in the discussions of the biologists gathered here this week for the annual meetings of the American Association for the Advancement of Science and its affiliated societies. Within recent months many workers in various parts of the field have discovered this well-known type of radiation to have literally miraculous powers to change the course of events in the development of living organisms, and to leave so deep an impress on their substance that their descendants, even to the last generation, will show the effect of their ancestors' experience.

Prof. Winterton C. Curtis and Raymond A. Ritter, of the Zoology Department at the University of Missouri, told of their researches on the effects of x-Rays on the development of growing tissue. They experimented on a small marine animal related to the jellyfishes, which reproduces itself by constantly budding off new individuals very much as a tree produces branches. After exposure to the x-Rays for ninety minutes the animals lost the power of producing new individuals, although the original parent portion remained alive.

THE CONTRARINESS OF x-RAYS

Prof. Robert T. Hance, of the University of Pittsburgh, told of some of the first results of x-Ray experiments on warm-blooded animals. The hair color of mice exposed to very light doses of the rays in his laboratory was radically changed. Normally "mouse-colored" mice of mixed ancestry went completely white after being rayed, while pure-bred mice of the same color changed in the opposite direction and became darker.

Dr. H. J. Bagg of Memorial Hospital, New York City, and Dr. C. R. Halter, of Cornell University Medical College, working in collaboration, were also among the first to obtain positive results with warm-blooded animals. Their mice developed certain marked bodily defects, such as only one kidney instead of two, abnormal eyes, and legs in bad condition at birth. Such defects occur among mice bred under ordinary conditions, but not so often as among rayed animals.

Plants as well as animals respond to x-Ray treatment. Prof. T. H. Goodspeed of the University of California, has obtained results in the breeding of x-Rayed tobacco plants which are comparable with those of Prof. Muller on fruit-flies. The new varieties produced in this way have a stronger growth and produce more flowers than their cousins descended from un-rayed parents.

Prof. L. J. Stadler, of the University of Missouri, has conducted similar experiments with corn and barley. In these, as in all the other animals and plants on which the treatment has been tried, the hereditary units or genes have been knocked out of place and more or less violently rearranged, resulting in forms of life wholly new to the universe.

It is agreed on all sides at the gatherings of scientific men that the past year has been one of revolution in the study of heredity among living things, comparable with 1859, when Darwin published the Origin of Species, and 1900, the year of the rediscovery of Mendel's law.

While the biologists attending this meeting of the American Association for the Advancement of Science were listening to accounts of newly discovered ways in which x-Rays affect living tissue, the physicists heard about another new property of these rays. Dr. Fred Allison, of the Alabama Polytechnic Institute at Auburn, Alabama, told the American Physical Society how he had found that they change the effect of certain liquids and other substances on light.

Many liquids, such as a sugar solution, have the property of turning the plane of polarized light. Ordinary light consists of vibration in an indefinite number of directions, but when polarized, the vibration is confined to one particular plane. If a beam of such light is passed through a sugar solution, it is still vibrating in one direction when it emerges, but in a different direction from that when it went in.

Dr. Allison has found that even liquids which do not ordinarily have this power gain it when exposed to x-Rays. When liquids, or glass, are placed in the field of a powerful magnet, they gain this property, as discovered many years ago by Faraday. When x-Rays are used in addition, says Dr. Allison, the rotatory powers of the liquids are increased, while in glass, it is made to rotate in the opposite direction.

Much might be said, especially in connection with the newer ray effects which have been recently announced. The "Penetrating Rays" of Mullikan, so powerful that they will wiggle their way through six feet of solid lead, whereas the most ambitious x-Rays are stopped dead by a half-inch of lead.

The Wynne rays—the new Coolidge rays—and others, are too abstruse to consider in this already extended presentation. The Death Rays—so-called because of their ability to suspend for all time our vital functions, merit one word in conclusion, and that word is—*Enough.*

ACKNOWLEDGMENTS

The Victor x-Ray Corporation of Chicago very courteously permitted the use of the cuts illustrating this article.

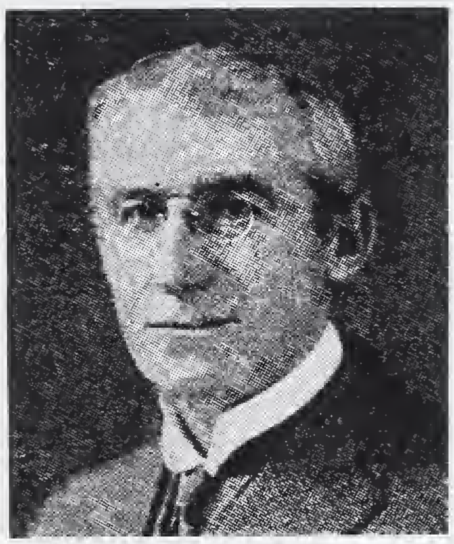
The following authorities were consulted in preparing the paper:

Applied x-Rays. *Clark:* McGraw, Hill Company, New York.
x-Rays. *Kaye:* Longmans, Green & Company, New York.
A Little Journey into the Realm of the x-Ray. Victor x-Ray Corporation, Chicago.

BUILDING STONES

By J. W. Sturmer
Dean of Science

WHEN WE TRAVEL about in Pennsylvania we see here and there stone houses which are quite old, dating back to early Colonial times. Some of these houses are in ruins, and even the stones in their walls show the result of "the gnawing tooth of time." How enduring, by contrast, appear the great hills of the Alleghenies, over which for many generations the Indians hunted deer—over which a century ago the Conestoga wagon trains carried the families of the early settlers, westward bound—and over which now fly the mail planes. We are inclined to think of the homes built by the hands of man as ephemeral, and of the great hills as everlasting. But are they, these hills and mountains, in truth, unchanging and eternal? Are the agencies which are operative in causing the weathering of our building stones ineffectual on the rock formations which make up the huge bulks of our mountain ranges?



J. W. Sturmer.

ON ROCKS IN GENERAL

If we look closely we find that quite the contrary is true: that certain kinds of old rocks weather and disintegrate, and that new rocks are in constant process of formation. We note also that rocks may undergo physical and chemical changes which transform them into rocks possessing new and quite different properties. These processes require, to be sure, long periods of time, and for this reason may escape our casual notice; but the evidence in proof of such changes in nature is irrefutable and cannot be ignored.

FROM ROCK TO ROCK

Our chemical literature is replete with references to the nitrogen cycle, and to the carbon cycle, in nature; and in like manner we could speak also of a calcium cycle, or of the silicon cycle, for a number of our familiar rock constituents play a part in vegetable and animal life, and in due course are returned to earth to play a part in the formation of new rock. Our

finest limestone is but the compacted mass of countless skeletons of minute marine organisms, and great areas of the ocean bottom are covered with calcareous debris of biologic origin.

The sandstone of our hills disintegrates, and the sand granules may be carried by water to distant regions where they are deposited in layers, and are again cemented together to form new sandstone. Thus the famous Sylvania sandstone of Ohio is referred to as of at least the third generation, and the original granules of silica may have been furnished by granite of a yet older rock formation. Mutation and change is the great law of nature, even as to its rocks.

But it is not our purpose to enter upon the speculative phases of geology. We merely wish to point out that it is natural for rocks to change, and that consequently we must expect changes in the rocks which we may have employed as building stones.

"Do rocks grow?" asks the small boy. And to this we must give the classical answer, "Yes and no." The boulders, cobblestones and pebbles turned up by the plough on a hillside located within the area covered by the glacial drift seem to occur as an annual crop; but their appearance at the surface is the result of the washing away—down hill—of the soil, and the individual stones are really smaller than they were when they broke off as fragments from the parent rock formation in the distant North, for in their long ride on the backs of glaciers they rubbed against each other, were rounded and polished, and thus were deprived of some of their substance. No, these rocks did not grow up from infant pebbles. But rock fragments may be cemented together in nature, just as we accomplish this artificially in the making of concrete; and this is one way in which rocks do grow.

SANDSTONE

Sandstone, for example, is such a rock. Imagine a sandy beach:—countless quartz particles, either from older sandstones which at some previous time disintegrated, or granules from weathered granite, transported by water, and deposited in this new location. What may happen to such a deposit of sand? Fine clay may be washed in between the quartz particles, and this clay may, by pressure and other causes, be hardened to a metamorphic stone, thus gluing the sand granules together to form a new rock, namely, "argillaceous sandstone." The Hudson River blue stone, much employed as a flagstone, is of this type.

Or, oxide of iron may wholly or in part account for the cementing of the granules, in which case the sandstone will have the charac-

teristic iron pigmentation, will be reddish in color; such a stone may, if it has sufficient hardness, and other desirable qualities, be quarried for building purposes, and be known as brownstone—a building stone quite popular a generation or two ago, but which has fallen into disuse, and is now "unfashionable." However, many of our old houses still have brownstone fronts.

There are yet other varieties of sandstone. The sand particles may be stuck together by colloidal silicic acid, which in time hardens to a flint-like substance, and thus forms a very strong and durable stone known as siliceous sandstone, which does not readily weather, because it does not appreciably absorb water, and thus does not crack by freezing. And being made up almost wholly of silicon dioxide, such a stone is not subject to chemical changes by the action of the constituents of the atmosphere. Hence it is quite durable. The well-known Ohio sandstone, known to geologists as Sylvania sandstone, is of this variety, and is extensively employed as a building stone. Many of the public buildings in Cleveland are constructed of Sylvania sandstone.

There is also a calcareous sandstone, in which calcium carbonate serves as the binder. This latter substance is the product of a chemical change. The insoluble carbonate may have been formed from the soluble calcium bicarbonate, which in turn results when carbon-dioxide-containing water comes in contact with limestone or other calcareous deposit; or the calcium carbonate may be a precipitate from a calcium sulphate solution. Anyway, the precipitated calcium compound becomes hard—rocklike—and binds the sand granules together. Thus a new stone is formed.

CLASTIC ROCK Sandstone is by the geologist classified as a clastic rock, that is, a rock formed by the reconsolidation of fragments of some older rock which has experienced disintegration. There are many kinds of clastic rock, but sandstone is of all these the most important from the standpoint of the builder. It is a familiar rock formation. It makes up much of the rock wall exposed in cuts through our mountains. The highly pigmented rocks of the "painted desert" are mostly sandstone. Our natural bridges, which add to the picturesqueness of western scenery, are arches of sandstone, the water having dissolved or washed away some of the less durable rock on which the sandstone had been bedded. Sandstone is quite abundant, and is widely distributed.

But there is sandstone and sandstone, and only certain kinds are suitable for building purposes. Nor is this suitability determined wholly by those characteristics which serve to classify the stone geologically, but rather upon such properties as strength, hardness, texture, color, imperviousness to water.

SHALE

Another clastic rock, the material for which is transported and bedded by water, is shale, a kind of hardened mud or mudstone, which also is usually colored and which may be tawny, red, brown, black, bluish or greenish. Shale, like sandstone is much in evidence as we view cuts through hills or mountains.

How does shale form? Many millions of tons of clay and silt are carried annually by the streams in the United States, some of it to be deposited at the point where these streams reach salt water. The delta of the Mississippi shows evidence of the bedding of mud, which is the initial step in the formation of mudstone or shale. Think how much clay has been transported by the yellow Missouri since the Sioux built their villages along its banks.

Rocks crumble. Their debris is carried toward the sea. As century follows century, our mountains are worn down to a lower level, their substance in time becoming the material for new rock formations. At intervals there is a gigantic upheaval somewhere, of sections of the earth's crust, and a new mountain range comes into being, in its turn to experience weathering, and to be worn down by flowing water and by other agencies, which bed the rock debris anew for yet another generation of rock.

Let us now center our attention on the mud, mostly clayey mud, which accumulates in the river flood-plains, and at the point where the river water flows into the briny ocean, where the colloidal clay is made to settle out because of the flocculating action of the salt and the other electrolytes in the sea water. From such mud deposits have developed the type of mud rocks which we call shale, a rock more or less friable and characterized by a ready cleavage conforming to its bedding planes. It frequently breaks up into plates which are concave on one side and convex on the other, giving the fragments a shell-like appearance, whence the name, shale. Because of the varying complexity of the composition of the mud which produced it, it may harbor a number of different chemical compounds in its substance. But it is essentially a modified clay, and clay is a silicate. So shale is a silicate rock.

SLATE

If now cataclysmic disturbances of the earth's crust take place, such as cause the birth of mountain ranges, such rock or shale may be subjected to enormous pressure, and, as a result, also to high temperature, conditions which are conducive to physical alterations, to chemical changes, and to chemical interactions between the minerals brought into close contact. In some such manner shale, and similar material, is transformed into slate, a new type of rock, harder than shale, and characterized by the fact that its cleavage is not in conformity with the bedding planes, which means that it is not in conformity with the layers in which the material was originally deposited. Slate contains minerals not present in the mud, nor in the shale, minerals which are products of the chemical alterations brought about by heat and pressure. It contains mica, and chlorite, which is related to mica, and it contains quartz, and probably carbonaceous matter, which makes it black, or hematite, which makes it red, while the chlorite imparts a greenish hue. Hence slate may appear in a variety of colors.

The grains of much of this matter constituting slate are flattened by great pressure, and for this reason, the slate splits readily into layers, a fact which materially assists in the quarrying operation, and in the production of slate shingles.

Slate is a characteristic metamorphic rock, meaning a rock altered by pressure or heat, either physically or chemically, or, as is the case in this instance, both physically and chemically. It exemplifies what the geologist means by the term metamorphism as applied to rocks.

Slate is found, as may be expected, in hilly country, and it is quarried in our own State, Pennsylvania, on an extensive scale. It serves many purposes—as treads for stairways, as flagstones, also for mantels, for counter bases, while much of our domestic laundry work is done in slate wash tubs. Slate blackboards and old-fashioned school slates are associated with memories of our earlier education. But the most important use of slate is for roofing shingles, many kinds and colors of which are now procurable. Some of the slates of pleasing color effects will neither fade nor change their tint, while other slates develop a different color on weathering, an effect particularly prone to occur if the iron in the slate exists as ferrous carbonate, which is subject to oxidation.

In the manufacture of slate shingles, about half of the material is waste. This, in the form of a coarse powder, is used in making artificial shingles, in which asphalt, or a coal tar pitch, serves as the binder. Slate powder is employed also as a pigment, and in various other ways.

SOAPSTONE Another metamorphic rock, differing in composition from slate, and much softer than the latter, is soapstone, which is employed, like slate, in making wash tubs and sinks, but particularly as table tops in chemical and bacteriological laboratories. There are many varieties of soapstone, some quite hard because of the pyroxene and quartz, which it contains; some quite soft because of its high talc content.

The Indians used soapstone quite extensively, because it can be carved with a knife; and in older brick homes, we find it used sometimes as a "trim." The coping on the brick wall enclosing the cemetery on lower Arch Street in Philadelphia, where Benjamin Franklin lies buried, is massive soapstone and its resistance to weathering is evidenced by the fact that when, two years ago, this brick wall was torn down and replaced, the old soapstone coping was good enough to be again placed in position, which was done. The softness of soapstone has its advantages, but it also limits its use, for it is easily scratched and marred.

Soapstone is not, like slate, a metamorphic product of mudstone, but more probably of a ferro-magnesium mineral, for it is rich in a hydrous magnesium silicate.

SERPENTINE A somewhat similar stone is serpentine, which is quite variable in composition, in hardness, and in color. Its characteristic constituent is a hydrous silicate of magnesium and of iron. The stone was quite extensively used a generation or two ago as a building stone, and many Philadelphia houses are built of serpentine, as are also some of the older structures of the University of Pennsylvania. Serpentine is usually green or greenish. A dark green, massive variety, which is capable of taking on a high polish, is used for soda fountains, mantels, counterbases, etc., as a type of "Marble." It is not a true marble, however, but a silicate rock. Its chief disadvantage lies in its tendency to weather, and to crumble, except for indoor purposes when it proves quite enduring.

GRANITE

If we look up the origin of the two last-named rocks in a book on geology, we shall meet reference to the term igneous rock—rocks produced by fire. And if we ask whence came this clay which forms soil, and may form shale or slate, we are told that the igneous rock called granite, a formation very ancient, even as geologists count time, a rock which makes up the cone of our mountain ranges, is its chief source.

Let us now briefly consider granite. Its appearance is quite familiar. We know it as a "grainey" rock, made up of dissimilar particles, some of one color, some of another. Its dominant color

FIG. 1

A photomicrograph of fine-texture gray granite (Wanamaker Building, Philadelphia), magnification about 10. The banded grains are feldspar; the clear, quartz, and the black, mica of the kind known as biotite.
Photomicrograph by Dr. Henry Leffmann.

may be light or dark gray, pinkish, red, or brown, or green. But when we examine it more closely, we find that the grains are not all colored. Some are colorless, or nearly so, glass-like and very hard. This is quartz. Then there are other grains, about the same size as those of the quartz, grains which are tinted—sometimes deeply tinted, and are not so hard. This is feldspar, a name which is generic rather than specific, and which refers to a family of silicates, of alumino-silicates rather, namely of potassium, or of sodium, or of calcium, and sometimes of a more complex composition. The feldspar in granite is crystalline. In addition to these two minerals, granite contains

also glistening scales of mica; and this mica may be either muscovite, which is colorless, and is, chemically, a hydrous potassium or sodium aluminum silicate, containing very little magnesium and iron, or it is biotite, which is black, and is essentially a magnesium and iron mica, containing also some little potassium and hydrogen. Granites are frequently classified on the basis of the kind of mica which they contain, whether the white or the black variety.

If a granite rock presents a layer-cake-like appearance, and splits readily in one direction, possesses what the geologist terms schistosity, it is not true granite. It is something else, a metamorphic product of a granite, called gneiss. The absence of schistosity or layer-like make-up, is one of the valuable features of granite. If the rock simulates granite, but shows crystals of larger size here and there, it is not granite but porphyry.

TEXTURE OF GRANITE

Granite may be fine-grained or coarse-grained. The fine-grained granite cooled and crystallized rather rapidly, the coarse-grained more slowly—which is in conformity with the principles of crystal-formation, as we know them from laboratory experience. And in the process of crystal formation from a cooling mass of fused rock substances, these latter crystallize out in a certain order, which is determined in conformity with their base-content. If the fused rock mass contained olivine, and pyroxene, a silicate of calcium, magnesium and iron, and hornblende, a mineral of similar composition, these crystallize out first, in the order named; then the feldspar, and lastly the quartz, which is compelled to assume the form of the interstices between the other crystals, and thus it cannot assume its own characteristic geometric outlines. This means that quartz in granite has a crystalline structure, but not a crystal form. It takes the form of the cavity in which it solidifies.

WEATHERING OF GRANITE

When granite weathers—and this it does very slowly—it is the feldspar and not the quartz which undergoes the change. The first evidence of weathering is the development of opacity in the feldspar crystals, this being due to the production of kaolin or clay, according to the equation—

$$2K\,Al\,Si_3O_8 + 2H_2O + CO_2 = \underbrace{H_4Al_2\,Si_2\,O_9}_{\text{Kaolin}} + 4SiO_2 + K_2CO_3$$

The products of the weathering allow water to enter readily and thus the change goes progressively forward. Freezing causes cracking of the rock, and eventually the granite disintegrates, yielding clay, quartz or sand grains, and some colloidal silicic acid. The alkali base, being quite water-soluble, quickly leaves for parts unknown.

Many of the boulders found in the glacial drift are granite, and the feldspar on their surfaces is usually opaque. But if the stone is cracked, the inside discloses transparent and unchanged feldspar.

The weathering of granite goes forward so slowly that it may be classified as one of the most durable of building stones. The hardness of granite is due largely to its quartz grains, for quartz is the hardest of common rock substances. Its color is in part due to the color of its mica, whether black or white, and in part to the coloring in its feldspar.

LIMESTONE

In the late eighties—before the days of "nut sundaes" and of the great multiplicity of fountain drinks, an old-time druggist had an old-time soda fountain. It was a square box of marble, set on a marble-top counter; the draft tube leaked, the drippings fell upon the marble slab, and in due course, ate a hole in it deep enough to hold a dog button or two. This caused much persiflage on the part of the drug store habitues who wondered what a beverage so powerful as to eat marble would do to their innards—whether it wouldn't be safer to stick to hard liquor, the effects of which were more fully understood, whether this new beverage was really a "soft" drink.

Of course, today all soda dispensers know that carbonated water will attack marble, but that it is harmless as a beverage. Those who have attended college know also that marble is a crystalline form of calcium carbonate, and that carbon dioxide and water convert this insoluble substance into the soluble calcium bicarbonate, which fact explains the erosion. They know probably about the so-called temporary hardness of spring or well water, due to the presence of this bicarbonate, and that warming, or even exposure to air, causes a precipitate to form in the water, because under such conditions the soluble bicarbonate reverts to the insoluble normal carbonate.

They may know that the stalactites and stalagmites found in caves, and Mexican onyx, which is so extensively employed in the construction of soda fountains, are the products of the solvent powers

of carbonic acid water, and of the reversion of the bicarbonate thus formed into the insoluble normal carbonate.

SEDIMENTARY ROCKS

Few realize, however, that our limestones, of which there are many varieties, are sedimentary rocks, formed largely by the aid of carbon dioxide and water, and that the older limestones are continuously being looted to furnish the material for newer formations—a process which has gone on continuously through the ages.

Our spring-fed fresh water lakes receive calcium bicarbonate from subterraneous sources. Some of this supply is precipitated because of the release of pressure, when the spring water enters the lake; some is precipitated because of the warming which the water receives; some because of the presence of ammonia, which is the product of decomposition of organic matter; and further a very considerable portion of the calcium bicarbonate is appropriated by clams, crustacea, fishes and various other creatures, large and small, which make their home in the water. These organisms assimilate an enormous quantity of the calcium salt, and ultimately, as we know, they are destined to cover the lake bottom with their remains, which thus become dominantly calcareous.

TRAVERTINE

When spring water has a high carbon dioxide content, and consequently becomes quite rich in bicarbonate, and if it bubbles forth into a mass of vegetation, the latter may become imbedded in the precipitate of calcium carbonate; and the bubbles of released gas, partly from the water itself, and partly from decomposing vegetable matter, will produce a porous condition in the resulting magma, which eventually hardens to form a type of limestone known as *travertine,* which is highly prized for floors, stair treads and for corridor walls in large buildings. Travertine is simply porous limestone.

CHALK AND LIMESTONE

Native chalk is calcium carbonate. It is prepared for pharmaceutical uses by grinding in water, and by elutriation or "water sifting," because it contains grit, which may be sand, or may be shell particles, for chalk is found in beds which were at one time ocean ooze, and this is made up largely of the disintegrated calcareous remains of small shell-bearing sea organisms, known as the foraminifera. Vast areas of the Atlantic

are covered with this ooze, the cemetery of countless billions of such creatures; and their shells are mainly calcium carbonate, absorbed from the sea water in the form of bicarbonate or other soluble calcium salt. Obviously, this bicarbonate was furnished by older layers of limestone, and this material, changed back to the insoluble carbonate by the help of marine organisms, is being laid down as a new stratum, which, if disturbances of the earth's crust bring it above the sea level, may form more chalk beds, such as we find on the English coast, or, if it becomes covered with great masses of other rock material, it may become compacted and form limestone. The limestone used in the construction of many of our fine buildings has a marine origin, and exhibits many fossils to prove its being a sedimentary rock—a rock sediment formed in water. True, it may be very ancient, as we count time, and in that long period may have undergone physical changes—may, in fact, show a crystal formation, or an approach to crystallized limestone which we call marble. When such changes are in evidence, the rock is of course classified as *metamorphic rock*. But as amorphous limestone, or as marble, or in any state between, it is the product of a sediment which formed in water, and its formation involves the chemical production of calcium carbonate. In a large measure it is $CaCO_3+CO_2+H_2O=Ca(HCO_3)_2$ and $Ca(HCO_3)_2=CaCO_3+CO_2+H_2O$. These equations account for the transference of tremendous quantities of matter from older strata of rock to forming strata, changes which have been in progress throughout the ages, and which will continue to the end of time.

WEATHERING

But even quarried rock, limestone or marble, which has been removed from its natural bedding, and is no longer exposed to the solvent action of ground water, gradually but surely wastes away. In the old cemeteries of Philadelphia there are many gravestones of marble which were put in place more than 150 years ago. These marble slabs are noticeably weathered, they are slowly dissolving, and their substance is being transported to other regions. We must remember in this connection that in industrial centers the processes of nature are supplemented by other destructive changes. For example, the marble gravestones, the marble facings on Independence Hall, the marble of the old Philadelphia Custom House, show the results of weathering so plainly because there is also in our city atmosphere some sulphuric acid, the product of the combustion of coal, a component of our chimney gas, which eats marble and converts it into calcium sulphate, a salt of appreciable solubility.

Neither marble nor limestone can last forever; but a polished stone weathers much more slowly than one exhibiting a rough surface, for the latter offers lodgment for water and soot, laden with corrosive acid. For the same reason compact, close-grained limestone or marble is more durable than more porous rock, a fact made evident by the present-day conditions of such stone in our old historic buildings.

FIG. 2

The modern method of quarrying Indiana Limestone by use of the channeling machine. (High-grade building stone is not quarried by blasting.)

Photo. by Indiana Limestone Company.

SEASONING OF LIMESTONE

When limestone is quarried, it holds a considerable amount of moisture, technically called quarry water. As this reaches the surface of the stone, the calcium bicarbonate, which the water contains, is precipitated as normal carbonate, tending to close the pores of the stone and to harden its surface. In the vernacular of the quarryman, the limestone "grows its skin," and becomes on exposure to air less porous and less absorbent. This drying-out process also effects a change in color, ultimately enhancing the beauty of the stone, but marring its appearance while the seasoning is in progress. There are in certain localities limestone deposits which hold absorbed rock oil; that is, crude petroleum, and

such stone, when used in building, is apt to become unsightly, because the exuding oil forms a film which catches and holds soot and other dirt to which a city building is exposed. A limestone of this type has been used in an imposing structure on Broad Street in Philadelphia, a building which has become sadly blackened.

COLOR Limestone, although essentially calcium carbonate, exhibits great variety as to hardness, porosity, texture and color. Travertine, a porous limestone, a kind of tufa, has been mentioned. Some limestone is soft and friable, and unfit for building stone, but may be of high purity, and for this reason be excellent for lime burning, and thus be destined to figure as a component in mortar, which after its "setting" constitutes one of our very important artificial stones—artificial calcareous sandstone.

TEXTURE Some limestone is wholly amorphous, some more or less crystalline, approaching the appearance of marble. Some presents the appearance of fossilized fish roe, being made up of countless round or egg-shaped particles, in a matrix of amorphous calcium carbonate. Such stone is known as oölitic limestone—from the Greek word oölon, which means egg.

CROWSFEET Some limestones and some marbles exhibit irregular zigzag lines, resembling the tracings of an earth tremor, obtained by means of a seismograph or the kymographic records of the heart beat. Such structure in rock is referred to by geologists as stylolite structure, while quarrymen speak of such tracings as "crows feet." Numerous theories have been advanced in explanation of crows feet, and indeed their origin may not in all cases be the same. But a plausible theory is to the effect that they result from the intrusion of foreign matter into fissures formed in massive rock, and to the enormous pressure to which such matter may subsequently be subjected. In case of Indiana limestone, the coloring matter of these tracings seems to be carbonaceous in character; in other words, it is due to organic matter which has been subjected to a chemical transformation comparable to the blackening of the soil in bogs and swamps.

The bluish color of some limestone, also, is due to finely distributed elementary carbon, while in others it is a mineral pigmentation. The yellowish and reddish colors are of course due to iron. When

iron is present in small quantity, and is uniformly distributed throughout massive limestone, it may add to its beauty. But accidental iron stains from nails, or from iron fixtures, are disfiguring, and it is extremely difficult to remove such stains.

LIMESTONE, SO-CALLED

Limestone is frequently associated with magnesite, magnesium carbonate, and when the two components are present in molecular proportions, the stone is known as dolomite. Dolomitic limestone and dolomitic marble are very common, are nearly indistinguishable, as far as appearance goes, from common limestone and marble, and are of importance as building

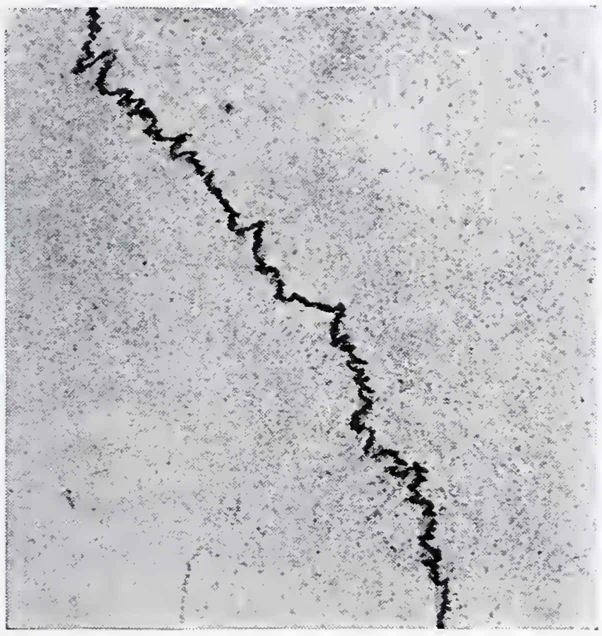


FIG. 3
Stylolite as seen in marble and in limestone.

stones. They are also largely employed as the source of magnesia and magnesium compounds, which figure in making a type of artificial stone, which chemically is magnesium oxychloride.

MARBLE

The terms limestone and marble are employed by builders much more loosely than is customary in books on geology or mineralogy; and much crystalline dolomite does service as marble, while the rich-appearing black and green "marble," so generally used for soda fountains, and for counter bases, is, in reality, a serpentine, a hydrous silicate of magnesium and iron, while the famous imported "Verd-antique" is a serpentine, mottled with marble or dolomitic marble. True marble is crystalline, and chemically is calcium carbonate.

When marble is very fine-grained, that is, consists of very small crystals, has a uniform texture, and is free from coloring matter, it is

classified as statuary marble. The famous Carrara statuary marble comes from a deposit in the Italian Apennines, where it is found enclosed in coarse-grained or common marble, and is said to represent only about 5 per cent. of the entire deposit. Beautiful statuary marble is quarried also in our own country.

QUARRYING

How limestone and other building stone is now quarried, the modern machinery employed in the quarrying operations, how it is sawed, cut to form, polished—all this is most interesting. But, as Kipling says, is another story.

PROPERTIES WHICH BUILDING STONES MUST POSSESS

It should be known, however, that a satisfactory building stone is a stone which possesses not only a certain chemical make-up, but which is also sufficiently dense, sufficiently hard, and which has the strength required for construction work. Some limestone, for example, is too friable, some sandstone is too porous, may absorb much water, and is thus subject to destruction by freezing. Some stone is too hard (quarcite) to admit of sawing and cutting. Some lacks uniformity of texture or of color.

As regards the strength of building stone, this should be comparable to a compression strength of about 10,000 pounds per square inch, a strength deemed ample for all ordinary work, for the load on the base of the Washington Monument is less than 7000 pounds per square inch, a load seldom exceeded in modern construction.

Building stones are laid in mortar, frequently in cement mortar. For the light-colored stones a white mortar is preferred. This calls for white cement. Let us pass now to a study of our modern cements.

ARTIFICIAL IGNEOUS ROCK

The building stones thus far considered are formed in nature's laboratory. But we need but look about us to note that artificial stone has come to be of greater importance as building stone than the stone which must be quarried.

There are first of all the bricks, and the varieties of tile, and of terra cotta—all artificial stone made by fire treatment from earthy material, hence artificial igneous rock.

The making of bricks dates back to the days of Nebuchadnezzar, and probably further. Indeed, bricks of that early period have been found in excavations made by archæologists, and the condition of

these ancient products of man's ingenuity proves the durability of baked clay. Probably no quarried stone is as resistive to weathering as a well-burnt brick.

WATER-FORMED ROCK

Then there is concrete, an artificial clastic rock, in which an artificial cement serves as the binder. Many of our modern buildings are essentially of concrete, with bricks or quarried stone used only for facing. And in this type of artificial stone, concrete, the hardening or setting is due to a chemical combination with water.

CEMENT

The oldest binding material for stone is clay. The Egyptians, as far back as in the building of their pyramids, employed a burnt rock, namely, burnt gypsum, which hardened with water. It was a product we now call plaster of Paris. The Romans also experimented with burnt rock, employing a calcareous rock for the purpose, and thus produced lime, which with sand and water forms mortar, and the setting of which depends largely upon the absorption of carbon dioxide, with the regeneration of limestone. Lime-mortar does not—and this is well known—set in or under water. But the Romans learned that if they used a mixture of lime and a certain kind of volcanic earth, called pozzolana, the mortar did set under water. Thus they deserve the credit of having discovered "hydraulic cement."

HYDRAULIC CEMENT

The art of making hydraulic cement was lost during the centuries comprising the dark ages, but was rediscovered about 1760 by John Smeaton, an English engineer, who produced such a cement by employing, for the calcining, a clay-containing limestone found in Cornwall, and mixing the calcination product with pozzolana. The concrete formed with this cement simulates, in appearance, a native rock found at Portland, which fact accounts for the name Portland cement, a name first used by an English bricklayer, who in 1824 was granted a patent on an improved hydraulic cement.

PORTLAND CEMENT

For a long time Portland cement was quite uncertain in its behavior, and frequently utterly unsatisfactory. But when it had been discovered that the material must be calcined at a certain temperature, that the crude materials must contain certain ratios of limestone and silicate rock, and that the

aluminum content must fall within certain established limits, it not only became possible to manufacture a uniformly reliable cement, but also to produce it from a variety of rock substances. The ratios worked out by countless experiments are now established. The cement clinker (the calcined product) must assay from 60 to 64 per cent. of lime, from 20 to 24 per cent. of silica, and from 5 to 9 per cent. of alumina, together with certain quantities of magnesia, some iron, and a little sodium and potassium—of course in combination. It should be understood that such assays must be interpreted, for the lime means so much combined calcium, and the silica, the alumina and the other substances figuring in the assay, are all in combination in the cement clinker.

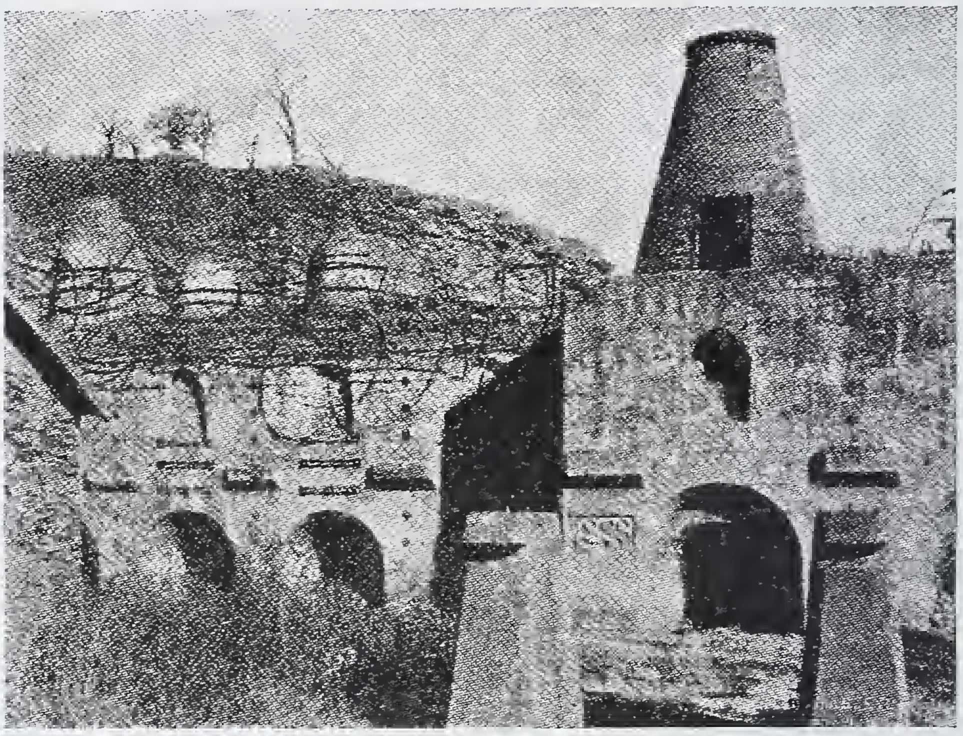


FIG. 4

Type of Dome or Vertical Kiln used in burning raw materials in the early days.

With the chemistry of cement fairly well understood, it becomes possible to make a satisfactory product out of a seeming diversity of crude materials. So we find that cement is now made from marl, from a clayey limestone, from some native rock with admixture of shale, or blast furnace slag, or clay. The important thing is to supply the calcium, aluminum, the silicon and the other elements in the right proportions. In the earlier periods of cement manufacture, when cement making was conducted by "rule of thumb" methods, the quality of the product varied considerably, for the elements of chance figured to a large degree. But cement is now quite uniformly dependable, and failure in concrete making is usually traceable to other causes and is not the result of poor quality in the cement itself.

MODERN CEMENT BURNING

Cement making is essentially a fire process; and as in other fire processes, the temperature employed is of great importance. Indeed, it has been shown that unsatisfactory cement of earlier manufacture was frequently the product of improper heat treatment, and not always due to the employment of incorrect mixtures.

In this country cement manufacture had its birth in the Lehigh Valley in Pennsylvania, about a half century ago, and the kiln employed, when the industry was in its infancy, was the old-time brick kiln. The cement rock was ground, mixed with water, the plastic mass molded into bricks, and these were dried and then fired. Nat-

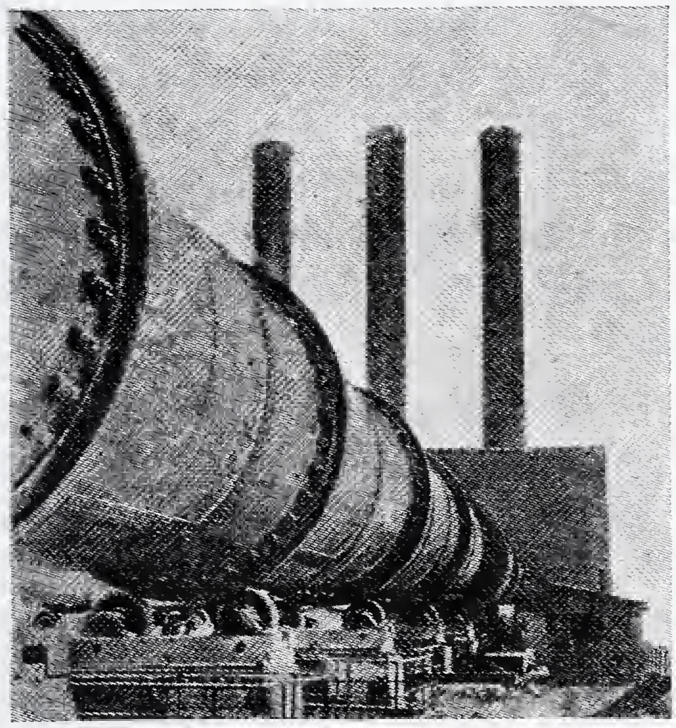


FIG. 5
One of the Rotary Kilns at the Hudson, New York, plant of The Atlas Portland Cement Company.

urally, there were many disappointments, for the bricks did not all receive the same heat treatment, and many were underburnt.

The modern procedure is quite different. There are, indeed, two methods employed, the wet and the dry; but this has reference only to the condition of the material in the process of grinding and mixing, the distinction between the two processes being of importance chiefly from the standpoint of the engineering problem connected with the preparation of the crude material which must precede the burning process.

It is—we must remember—the burning—the high heat—which actually converts the clay and limestone, or whatever else may take

their places, into cement. And this conversion is the result of certain chemical reactions. Cement clinker is an artificial igneous rock.

The kiln now employed is a huge cylinder, sometimes 250 feet in length and about 10 feet in diameter. This great cylinder is supported in an inclined position, one end higher than the other, and rotates uniformly during the operation, like an old-fashioned coffee roaster. In a kiln of this kind about 2500 barrels of cement can be produced every twenty-four hours.

It is charged at the higher end, and as the "mix" works its way along—by gravity, aided by the turning—it is subjected to progressively higher and higher temperatures, up to about 1425 degrees C., for the fuel enters at the lower opening. The passage of the material through the tubular kiln occupies about two hours; but the process is really continuous, with "raw mix" entering at one end, and cement clinker, in granules the size of cherries, discharging at the other.

When the clinker has been ground to an extremely fine powder, and mixed with the right quantity of ground gypsum, to slow down the initial setting to the rate at which cement can best be worked, it is ready for the market.

CHEMISTRY OF CEMENT

While the burning is a continuous operation, the material in its progress toward the hottest zone experiences certain chemical alterations which are not simultaneous, but which occur in a definite sequence, governed by the rise in temperature. First, the uncombined water is driven off. Next, the organic matter in the clay or the marl is destroyed. Then the calcium carbonate loses its carbon dioxide and is changed to lime. The latter, at the high temperature now reached, interacts with the alumino-silicate in the clay, or in whatever silicate material may be used in place of clay, and forms a calcium aluminate which may be represented by the formula $(CaO)_5(Al_2O_3)_3$. Also a calcium silicate of the formula $(CaO)_2\ SiO_2$. As the temperature rises to about 1400 degrees C., these two compounds interact with more of the lime, forming, eventually, tricalcium silicate, $(CaO)_3\ SiO_2$, and tricalcium aluminate, $(CaO)_3\ Al_2O_3$. The formation of the tricalcium silicate, $(CaO)_3\ SiO_2$, is of the greatest importance, and its presence in the finished product really characterizes modern Portland cement, and differentiates it from the cements of an earlier period.

As has been stated, proportions of the base, namely the lime, to aluminum, figured as CaO and Al_2O_3, respectively, and to silicate,

figured as SiO_2, must be right; but magnesium also figures as a base, while the iron present may constitute an acidic factor. The sodium and the potassium produce low-fusing silicates, which aid in the sintering, that is, in the production of clinker by partial fusion. The setting of cement depends upon its affinity for water, with which the calcium silicates and the aluminates enter into combination which are in part due to colloidal phenomena, and in part to true hydration. The combined water thus becomes an integral part of solid rock—artificial rock. Just as in nature we find combined water in gypsum, and in many other well-known minerals, so does it exist also in hardened concrete.

THE SETTING OF CEMENT

But the hydration of cement is not as simple, chemically speaking, as is the setting of plaster of Paris, for in the latter case a definite quantity of water combines to reconstruct the mineral.

In the setting of cement there forms first a gelatinous magma in which definite hydrations and chemical reactions go forward, and in due time minute crystals also take form. The initial setting occurs in the first hour or two, and it involves principally the hydration of the tricalcium aluminate. Then the tricalcium silicate comes into play, and lastly, the dicalcium silicate appropriates its quota of water. There is involved further the decomposition of some tricalcium silicate, with the liberation of calcium hydroxide and colloidal silica, which latter, it will be remembered, figures in nature as the binding or bonding material in a certain type of sandstone.

OVER-NIGHT SETTING

The whole process of setting and hardening occupies a long period of time, indeed many months, during which concrete increases in strength and firmness. The tardiness with which Portland cement hardens, slows down building operations, for each unit of concrete must have time to set firmly before it can carry a load without crumbling. Moreover, in freezing weather the use of ordinary cement is, because of the slowness of its setting, impracticable, for the crystallizing of the free water in the "mix" involves expansion, which must of necessity produce cracking and crumbling. A quick-setting cement is, therefore, a necessity for winter use, and is frequently needed at other seasons of the year when speed in the construction is of primary importance. Such a product is now manufactured on an extensive scale. It hardens over night.

It is not injured by freezing, for not only does the speed of the setting preclude this, but there is an additional safeguard in the fact that in the setting much heat is liberated which helps to keep the concrete warm during the critical period.

CHEMISTRY OF QUICK-SETTING CEMENT A quick-setting cement is chemically characterized as a high alumina-cement, and its chief constituent is a calcium aluminate, $CaO.Al_2O_3$. Its silica content is very low, hence silicates are nearly negligible in its make-up. In the manufacture of high-alumina cement the native aluminum oxide, bauxite, replaces clay, which is a silicate, and a large amount of iron figures also, and appears to be necessary.

An assay report of Portland cement and of high-alumina cement shows the difference in the composition of these two important products.

Portland Cement	Average	High-Alumina Cement	Average
Alumina, Al_2O_3,	9 %	Alumina, Al_2O_3,	39.5 %
Lime, CaO,	62 %	Lime, CaO,	39.9 %
Iron Oxide, Fe_2O_3,	3 %	Iron Oxide, Fe_2O_3,	15.4 %
Silica, SiO_2,	22 %	Silica, SiO_2,	2.59%
Magnesia, MgO,	2.5%	Magnesia, MgO,	.73%
Sulphur, SO_3,	1.7%	Sulphur, SO_3,	.21%

In the setting of high-alumina cement the mono-calcium aluminate, which is its chief constituent, is changed into hydrated tricalcium aluminate and hydrated alumina. In what manner the iron figures in the setting is still a chemical mystery.

TESTS The progress in the setting and hardening of the two types of cement may be expressed in resistance to crushing by compression, the test being applied to a concrete made from each with sand and pebbles. Such a comparison shows that high-alumina cement furnishes a harder concrete in twenty-four hours than can be obtained from ordinary cement in a month's time.

WHITE CEMENT The uses of cement are many and various; and for certain purposes the color of ordinary cement is objectionable. There is accordingly a demand for a colorless production, that is, for a white cement. This is now readily

obtainable, but is, as may be expected, more costly than ordinary cement. In its manufacture the materials are carefully selected. The limestone must be white and free from iron. Common clays which always contain pigment of one type or another, cannot be used, and must be replaced by kaolin or china clay; and the fuel employed cannot be coal, but must be fuel oil. It should be known, however, that white cement is a real Portland cement, and that it contains the di- and tri-calcium silicates, which means that it hardens like ordinary cement, through a long period of time.

Much white cement is used for stucco, for which its superiority is obvious, as it can be tinted in delicate colors. It is used also for cast pieces, statuary, bird baths, lawn benches, columns, cornices, etc., for white mortar, and for other types of artificial stone. Terrazzo, now so generally used as a flooring in public buildings, is usually made with white cement, which forms the matrix for the fragments of marble of various colors, characterizing this kind of artificial stone.

The cast building blocks, known as artificial granite, are in reality concrete in which selected crushed stone replaces pebbles, and here also white cement is desirable.

WATER-PROOFING

Concrete is more or less porous and absorptive, no matter what type of cement may have been used in its production. But there are several processes of making it damp-proof, or water-proof. To make it damp-proof, it may be coated with soap solution, and then with a solution of alum, thus forming an insoluble aluminum soap; or it may be coated with sodium silicate solution, which, on the absorption of carbon dioxide from the air, yields colloidal silica. Sometimes a solution of paraffin in gasoline is employed to prevent absorption of water. To make it water-proof, which means proof against water under pressure, a bituminous shield may be supplied, or lime, or soap, or mineral oil may be incorporated in the concrete itself.

This tendency to absorb water is not inherent alone to concrete, but to the unmixed cement as well. Hence great care must be exercised in its storage and in its transportation. Cement companies have immense tanks, which look like huge silos, for the storage of their product.

OUTPUT OF CEMENT INDUSTRY

The cement industry has in recent years grown by leaps and bounds. Cement is now made in twenty-nine States, located in different sections of this country, and the output has reached the imposing figure of 175,000,000 barrels a year. About one-fourth of this amount is furnished by the cement works of the Lehigh Valley, where the industry had its start about a half century ago, and where it has reached the highest development.

There are other mineral products which "set" by combination with water. Keene's cement, for example, a twice-burnt gypsum—burnt the second time after the addition of alum, or some other chemical. Then there is the basic chloride of magnesium, sometimes used as a floor covering. But the quantities used of these two substances dwindle into insignificance when compared with the output of Portland cement, and its cousin, the high-alumina cement. The Panama Canal was a cement job. Colossal dams, and great hydro-electric developments are made possible by Portland cement. The modern skyscraper is of steel and cement, with natural stone or brick used merely as facing. Countless homes are cement houses, and much of our stucco is a cement product. Concrete is indeed the great building stone of modern times.

THE PRESERVATION OF FOOD

By Louis Gershenfeld, Ph. M., B. Sc., P. D.

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MANY OF US LIVING in cities possess imaginations that frequently do not extend beyond the city limits. The majority of people are but little concerned about the processes necessary for transforming crude material into finished, delicate and palatable foodstuffs, and so preserved that they may be made available only when our desires for them are aroused. But few seem to appreciate the many revolutionary changes that science has introduced, so that life-sustaining food may be at hand at all times. Every now and then, however, some of us become annoyed, when the corner storekeeper informs us that a certain food which we enjoy is off the market, or that there is a shortage when more annoyance still is displayed when the bill is presented.

Louis Gershenfeld, Ph. M., B. Sc., P. D.

So that we may appreciate and understand more fully the present methods, which are practiced in the preservation of foodstuffs, let us start the story by picturing before us the cave dwellers.

BACK TO NATURE

The magnificent and beautiful things which have transformed this world are gone: automobiles, aeroplanes and all facilities of transportation; hotels, flats, homes and barns; and even clothing, the little that remains on some of us, has disappeared. We are really back to nature; but let us see whether with the closeness to nature, we are happier, considering that all of our modern facilities are out of the picture.

From a distance someone is seen approaching. He is walking and climbing and now and then resting, as he sways along the narrow rocky path. But suddenly the figure stops, and with our field glasses (for these we retain that we may see the picture), we observe a large, ugly, hairy creature, holding a heavy, broad stick in one hand and carrying some game on his shoulder. He rolls away a huge stone and from the cave, a few creatures similar in appearance to the one just described walk out. The meat is soon torn apart by the eager hands,

and down it goes as quickly as it is removed. Finally one by one they all withdraw into the cave, leaving the remnants behind. Hunger is satisfied.

You will say this is not a pleasing picture. 'Tis true, but remember that this is primitive man. To sustain his existence, he found out that food was needed, and with his one track mind, he occupied himself nearly all day to get his food supply for that day.

THE FIRST REFRIGERATOR

With the cave dweller, it was not a question of doing today what can be done today, it was you must kill today if you wanted to eat today and live tomorrow. It was a pressing problem that faced him daily. But primitive man was soon forced to do something. He found that it was not always possible to get his daily supply. Weather conditions probably interfered then as they now do at times. Something had to be done. One day, however, when in distress and desperate for the want of food, he began to tear with his strong teeth upon the remains of some game which he had caught the day before. As remnants these were thrown away and were found later in a cold corner in the cave. To his surprise, he found that they were fit to eat, and that they possessed practically all the characteristics present when fresh. So here we have the first step in the process of the preservation of food, and in the natural coolness of the cave, we have the principle of refrigeration. It is perhaps here too that the story begins when discussing the conservation of food (the problem of storing food in plentiful times to be available in times of want) ;—yes 'tis even our first lesson in thrift.

In the progress of evolution, primitive man developed some process of reasoning, perhaps imagination, and may we not even call it a crude method of experimentation and research. Herbs, roots and other plant materials were tried for their ability to satisfy as foods. Here we have the beginning of a consideration of a variety in our daily rations, true not from a scientific standpoint, but in its own way, it has perhaps proven of value as the basis for the starting of a study of the scientific value of foodstuffs. And then the cave dweller, thinking, in his own way, how to profit by his experience with the game, began to investigate in a crude way, the keeping qualities of these herbs and roots, etc., in the cool quarters of the cave. Gradually, we have a picture of primitive man improving his state of life.

Now, in this swiftly moving universe, where a year is but a day, and a century just a little while, we will pass by many of these centu-

ries, for the picture concerning the preservation of food is about the same with but little improvement. And here we are looking at the ways of the people in ancient Rome, where splendor and even luxuries are known. We find that mortals are not bound to their own immediate environment to find and select their food supply, for transportation facilities are now available. It may be a line of slaves bearing a heavy burden (containing food to sustain life but delicacies as well), and compelled to move on by the stinging lash of a whip of an imperial soldier. It may even be some other crude method of transportation, bringing necessary food or perhaps snow and ice from the mountain tops and other available places, so that the Emperor may have a variety of foodstuffs and possibly artificial refrigeration to cool and even unknowingly to preserve these. The wheels of progress have moved on. Transportation has made more easily available a variety of foods. Artificial refrigeration is perhaps made available in that nature's ice is moved from one quarter to territories nearby, where it is not plentiful, and used there to cool drinks and possibly to preserve foodstuffs.

As we gaze through our glasses, we see the centuries moving on and what do we find as the big problem at all times? It is the need of food to satisfy the hunger of the poor and the appetites of the rich. It may be one of want or one of gluttony. The hunger instinct is a basic fundamental instinct. At this period of man's existence, the food question, one of satisfying this hunger, is not only the principal problem, but a most difficult one. There may have been times in all or some localities where the keeping of food was not a pressing problem, for it may have been always available in sufficient quantities to be eaten fresh. But when preservation was needed, cold temperatures supplied by the means briefly mentioned were employed.

Our picture leads us now to those glorious days preceding the Elizabethan period. We are on the verge of great changes in that the diet is more varied and the food eaten, if not more wholesome, is at least more palatable. Much concern was given to the seasoning of food with spices, but comparatively little improvement was noticed in the use of other methods for the preservation of foodstuffs. In this age of spices, for the latter played an important part in the commerce and history of these days, there is the possibility that the use of these condiments not only served the purpose of bringing new and delicious flavors to our old dishes, making food in general more inviting, but that in some cases, there was an actual preservation of the food by

the spices and condiments. Foods which could not keep well before the addition of the spices, seemed to be capable of standing about for longer periods of time. It may be, as is the case even today, that there was a slight decomposition of these foods, but the odor and taste were masked by the presence of the spices. Still there is also the possibility that some of the recipes were actually prevented from spoiling, and perhaps we have here the beginning of the legitimate preservation of foodstuffs by chemicals and drugs. This is of course only problematical, for scientific methods of study are not ready to appear in the picture.

BACON AND PRESERVATION

We now find ourselves viewing the intellectual and gastronomic glories of the Elizabethan period, and what does our picture inform us? Food again—yes, always food. Marked progress in the preservation of foodstuffs had not been made. Most desirable foods were perishable, decomposed readily and had to be eaten while fresh. Today's abundance was unable to give much towards tomorrow's supply. But at this time, we are privileged to record the first scientific study and research of the value of the cold of the snow as an agent to preserve food. History tells us that the great scholar, philosopher and scientist, Francis Bacon was a martyr to the cause of the preservation of foodstuffs. As a contributor to science, interested in civilization and in the health of all people, Bacon's curiosity was directed towards the problem of preserving food. It is said that on a snowy winter night, he was struck by the thought that the cold of the fluttering snowflakes, found clinging to his carriage (as he was riding along), might help to preserve foods. He immediately ordered the driver to stop, went out and bought a dressed fowl. This he packed tightly with snow. Due to the exposure both in obtaining the fowl and in performing the experiment, Bacon was seized with a severe cold, and died a few days later. Before death, it is said, he asked an attendant if the snow-stuffed fowl was keeping. This was Bacon's last contribution to science, and as we may view it now, having approached the beginning of scientific research in the preservation of foods.

If my story was one concerning the production of methods for cooling our foods and drinks, I might have mentioned history informs us that the Egyptians knew the secret of cooling by evaporation. They made natural ice just as the natives in many of the Asiatic and African countries make it today, and that is by leaving shallow trays of water

exposed to the night winds. Alexander the Great dug trenches to store snow. Old formulas and recipes for frozen creams and ices are to be found in the writings of days gone by. But the cold obtained by these various natural means in olden times was mainly for the cooling of food and drinks. Preservation by these methods was practiced to a limited extend or not at all, and inasmuch as my story is about the "Preservation of Foods," I will only relate facts and data in which preservation is the purpose sought.

PILGRIM'S PROGRESS

We now approach the days covering the last three or four centuries. We will therefore direct our attention to the picture in this country. The Pilgrims had arrived and before long starvation stared them in the face. The Indians kept the men from hunting or stole what they could collect. Nature may have been unkind at times in the amount of food which was supplied, but greater losses were exacted due to the spoilage of foods that were collected. Something had to be done to insure an adequate food supply and keeping the spoilage down to minimum. The result was the underground cellar, a warehouse where food could be stored, better protected against theft and where the coolness of Nature's earth could preserve it. What we have here is however nothing more than the same principle which the cave man discovered.

And what does the picture show us in those pre-revolutionary days? What were the methods of preservation which they practiced? Most foods were still perishable, and were to be eaten before they spoiled. The underground coolness or the short duration of cold from icy waters were the means whereby cold was supplied as the preserving agent. The path of civilization had changed, everything was more inviting, living conditions had undergone a radical change; and foods were made more palatable, more eatable, the old dishes having new inviting odors and delicious flavors. But the all-important problem of food preservation had made but little progress. Now as we approach more recent days, we may find a picture which is perhaps more pleasing, but the underlying principle of preservation, the problem of keeping food from spoiling, is to be found in methods which depend upon nature's coolness, just as we have it when first introduced by primitive man. These cooling conditions may have been in the cellar or the depths of the well or perhaps the old spring house, where cold water of the winding stream coming from the hillside springs in some far off land was imprisoned, even if only for a few moments, but long

enough to supply to the enclosed environment a degree of coolness, that aided materially in the preservation of foodstuffs. Even in these modern days, the spring house may be found in rural districts, a spring house in which the cold may come from water supplied by a running stream or merely from the natural coolness of the earth, again the caveman system. Spring house and well facilities are adequate methods of refrigeration, but the use of such facilities is limited, and people in populated districts cannot use these as refrigerators. Our picture now is approaching our own days. People began to live in closer contact with each other. Towns and cities were born. Food was needed for their inhabitants, yes food in quantities that were not dreamed of before had to be transported and kept, quickly to be made available when needed. Something had to be done to preserve perishable foods. Necessity as the mother of invention, is now portrayed in this picture by those large sheds found in the colder parts of the country, where immense territories are filled with blocks of ice, stored there during the winter season and packed in sawdust, hay, etc.—and to be unpacked and shipped when wanted, during winter or summer. This is ice, cold water in packages, a crude but desirable key in the first step in modern refrigeration. 'Tis a means of having something available both winter and summer, so that a low temperature may be made available to preserve our perishable foods, which now, because of necessity, had to be kept longer, as it would take considerable time for their collection, transportation and distribution. Methods were devised so that individuals could store this ice and thereby receive the benefit of the cold which this imparted to any environment. So we see before us a simple device of a covered vessel holding the ice, surrounded by the foodstuffs, or the zinc-lined box insulated so as to retain the cold, and the many other types of old-fashioned ice chests. The water formed by the melting ice had to be emptied at frequent intervals. From the simple ice chest or container, an improved refrigerator was introduced. Here the ice and foodstuffs were kept in separate compartments of a cabinet usually covered with insulating material. The water was allowed to flow into a pipe attached to the ice compartment and then connected to a waste pipe. The foodstuffs did not come in direct contact with the ice, but were kept fresh by the cold imparted by the latter. The size of these refrigerators varied from the small chest used in the home to those used by dealers in foodstuffs or in the old type cold storage plants, where foods were kept until the demand for them necessitates their removal.

ARTIFICIAL ICE As we follow the picture, we find, however, that natural ice had its limitations. It was not always possible to store sufficient quantities during the cold months to meet the demands for the whole year round. Nature did not work in harmony with the ice trust, for some winters were milder than others. Then one had to consider the expense involved in the matter of transporting this natural ice from the colder regions. This necessitated a study of the possibility of making ice artificially, so that a sufficient supply could always be at hand, and, if possible, at a reduced cost as compared with the natural product. There were many early workers in this field of science. In 1775, Dr. William Cullen invented the first machine which produced ice by purely mechanical means. He was followed by Vallance of France (1824), Perkins, an American living in England (1834) and Dr. John Gorrie of Florida, who in 1850 procured the first patent in this country for the practical process of manufacturing ice. Some eighty years ago, or to be exact, in 1850, we have Dr. Frederick Carré, a Frenchman, introducing the first apparatus (ammonia machine) for manufacturing ice artificially on a basis making possible competition with the natural product. Soon other methods were perfected, including machines by Linde of Germany and David Boyle in this country, and thereafter we have introduced many new forms of apparatus which were improvements over the old. Artificial ice gradually replaced natural ice as the means of supplying the cold necessary for the preservation of food. In fact, today, with an actual sale of approximately fifty-seven million tons annually, there is almost three times as much artificial ice supplied in this country as compared with the natural product. We now come in direct contact with the fact, that science had taken a hand on a more elaborate scale in this vital problem. From now on, our picture will show that science is at all times directing the movements behind the methods which we employ in the preservation of foods. The relation of pure food to the prolongation of life, and the matter of its preservation and subsequent economy to us as made possible by science is very important and interesting reading, and something which is often overlooked by the layman. Our picture may direct us to the practice of the many methods other than refrigeration that are after all methods of preservation. For chronological exactness, these should be mentioned at this time, but so as not to lose our trend of thought, may I complete the story of refrigeration before a review of the other methods are considered.

In this country the earliest record of delivery of ice to the home is in 1802. Three years later, Frederick Tudor sent a shipload of natural ice from this country to the West Indies to help keep down the ravages of Yellow Fever.

In 1875, a cargo of meat frozen by a refrigeration machine arrived in England from this country, and the food was in a sound condition. In 1880, a successful voyage was accomplished by a refrigerator ship sailing from Australia and arriving in England, with the meat in a satisfactory condition. Refrigeration by machine, making it possible to control temperatures during storage at any desired degree in all weather and seasons, any place and any time was soon recognized as a commercial success. Its use was extended, so that any food could be subjected to the influence of the preservative action of cold even during transit. Can you realize the influence that cold storage and refrigerator transportation has had on the development of our food habits and even our whole social sytem? Can you realize the saving of energy, time, health and even life itself? I will leave this to your imagination, for my story will be a lengthy one even without showing you these beneficial results.

The real beginning of the manufacture of ice artificially so as to compete with the natural product and its finally reaching a point where it is gradually replacing the natural product was in 1890. The greatest shortage in the crop of natural ice that ever occurred in this country happened at this time. Mechanical refrigeration stepped in to care for this unusual shortage and since then the ice-making and refrigerating industry has rapidly developed. Today, in this country alone, we use yearly about fifty-seven million tons of ice.

If we turn our picture so as to observe the conditions in the home today, we will find that in place of the cellar, or spring house, or even the daily delivery of natural or artificial ice, the principle of machine refrigeration is employed by the electric refrigerators. These are icing units placed in any suitable cabinet and operated by plugging into the nearest electric outlet in your home, and of course being modern, your home is wired. The result is an uninterrupted service, a temperature colder than that given by ice, and one which is uniform at all times, whether you are home or away for some length of time. Even if the cabinet or refrigerator is not insulated sufficiently, or it may be necessary to keep it in a place where the sun may reach it, the

icing unit keeps its temperature uniform and at freezing temperatures. There is avoided the possibility of the cabinet becoming an incubator, as would be the case under such conditions if the ordinary refrigerator and ice box were used.

It will be impossible for me to continue or attempt to review the other methods of preservation without briefly mentioning the important facts concerning the value of foods, and the important causes of food spoilage and deterioration.

The Value of a Variety of Food

The scientific study of food has followed certain definite trends. As early as 1840 it was recognized that proteins, fats, carbohydrates, mineral matter and water were the component parts of food tissues. Continuously thereafter chemists were investigating constituents of food substances, and by 1895 Atwater and his associates in this country had examined and listed the chemical composition of most common foods. About this time, it became common to classify food substances wholely by their caloric value or the amount of energy that they would yield to the body when taken in and properly digested. The next two decades added to this fundamental knowledge the observations concerning those mysterious substances known as the vitamins, so that McCollum and Davis were able in 1915 to formulate a theory of adequate diet. At that time, they said that a diet must contain in addition to proteins, carbohydrates and fats for energy, inorganic salts for the building of the body and vitamins A and B necessary for the proper growth and development. Later additional vitamins became known, so that the alphabetical category includes A, B, C and D quite definitely established, and possibly vitamin X or E necessary for reproduction. When considering the value of any food today we take into account all of these various factors, and, as is obvious to almost any one with a fundamental knowledge of foods, no single substance provides all of the necessary elements for adequate nutrition. For instance, milk is, no doubt, the most satisfactory single article of food consumed by man, but milk or any other food is not a complete food when taken over a long period of time as the sole source of nutriment. One of the troubles with milk is that too much bulk is required to satisfy the body's need. It contains 87 per cent. of water and 13 per cent. of dissolved substances; it happens to be rich in both calcium and phosphorus, whereas many vegetable foods

are rather poor in these elements. Indeed, only the milk of animals and the leafy vegetables contain enough calcium to satisfy the needs of man.

If nature has provided a single and complete food, it still remains undiscovered or if such a food exists, the human body has not as yet been adapted to its use. It is, therefore, necessary to be supplied with many different kinds of food so as to obtain the many principles necessary for the body's need. You can therefore appreciate one of the main reasons for the necessity of a variety of foods.

There is no law of man or of nature that compels the thinking human being to limit himself to milk, wheat, oranges, nuts, or anything else in the food category. If he is really intelligent, he will want to make up his diet of a sufficient variety of foods to provide everything necessary for the proper development and stability of his tissues. He will want to satisfy the esthetics of his appetite and the limitations of his digestive apparatus. Investigations have shown that fresh fruits especially citrous fruits and certain raw vegetables (green leaves, sprouting grains, etc.) ought to be included in the diet, to provide adequate amounts of vitamin C. Scientific studies have shown that the proteins of the muscle of the liver and kidney are more valuable as a supplement to cereals and fats than are the proteins of milk. Indeed, it is not even certain that milk always provides an adequate amount of vitamin B, and it is known that various samples of milk differ as to their quantities of vitamins A and C, the latter and vitamins D and E even being absent altogether in some samples. Eggs contain everything necessary for the growth and maintenance of the body, but are poor in calcium and unbalanced in other food principles. On the other hand, oysters, clams and crabs contain all of the uncharacterized food substances, including iodin and vitamin C. And again we must take cognizance of the fact that we may not be necessarily satisfied to exist on foods just because they are more useful and more necessary than others. The longing for some foods not as nutritious may be at times just as imperious, just as urgent as the longing for a piece of bread and butter or a glass of milk, so that sometimes we may have to satisfy a hungry heart instead of a hungry stomach and perhaps at the expense of the latter. Remember there is also a growing consciousness that the luxuries of one person may actually be the necessities of another. This hasty review is indicative of the importance of a varied diet for man.

Spoilage and Destruction of Food

Nearly all foods are subject to infestation by insect pests. Some of the latter may cause disease in man if they are consumed with food. Other non-disease producing parasites may impart an odor, so that the food becomes objectionable, and last but not least, there are parasites which perhaps we humans never see but they are about, always ready to devour or destroy that life-sustaining food, before it reaches our table. A book of several hundred pages can be written covering plant diseases alone, and our efforts in combating these. Millions and millions of dollars are spent annually to fight bugs, other insect pests and insidious diseases to which our crops and foods may have fallen victims. Can you realize that it is easier to get an appropriation of millions of dollars to fight the European cornborer, the Japanese beetle, red spiders or other pests attacking our plants, than it is to obtain a similar amount to prevent humans from contracting disease? And just because it is our food, which is being destroyed. One after another, our crop plants have fallen victims to insidious, infectious diseases, especially the so-called "mosaic maladies." Corn, cucumbers, cane fruits, lettuce, potato, tomato, spinach, and many of our flowers used for decorative and other purposes have all suffered. Other plants are not immune. Cornborers, Japanese beetles, red spiders, leaf hoppers and hosts of other destructive pests and destroying organisms are threatening the food supply of humans in their contention for the right to exist. Were it not for the methods instituted by scientists, insects and plant diseases would rob us of at least 50 per cent. and probably 60 per cent. of our crops. As it is, in spite of the present methods to control their ravages, plant diseases and insect pests are taking a toll of from 12 per cent. to fifteeen per cent. of all food which is raised. And how about the rat menace? Here alone we are losing annually, in this country, food, possessing a value of approximately one-quarter billion dollars. These diseases and pests, remaining beyond our reach or difficult at present to control are in reality a menace and a challenge to humanity. Scientific and technical skill, patience, constant application and a large supply of money are required to overcome these enemies that are constantly attacking our food. The public are but little concerned or do not realize these facts, for being less tangible enemies that threaten us, these invaders seem too remote for most individuals to become annoyed or concerned about them.

Bacteria or products produced by bacteria are perhaps the greatest offenders, causing the spoilage of food. The yeasts, molds and many members of still lower forms of bacterial life play an important part in the changes taking place in foods, so that most methods for handling foods have been so developed today as to exclude these organisms or to prevent them from exerting their effect. Insect pests which attack foods cannot breed and bacteria which decompose the latter are prevented from developing and exerting their effect at the temperatures generally present in the ice box, refrigerator or cold storage. Foods at cold temperatures are therefore protected from decomposition as long as the temperature remains low. It is important to remember that these low temperatures do not kill the microorganisms (only after exposure for long periods of time), so that if originally present, they are always ready and capable of developing, if the temperature becomes favorable. It is therefore important to avoid outside contamination by keeping ice boxes and all refrigerating devices clean, dry, and well aerated, and always be assured that there is sufficient ice (if this is employed), and that there is no faulty construction in the refrigerator. Some foods exposed to air (in particular the oxygen in the air) may change in color, flavor or otherwise display a pronounced destructive effect, resulting in spoilage. It therefore may be necessary to keep such foods in covered containers and preferably in the cold, as changes by oxygen are greatly reduced at low temperatures. Light may effect some foods if the latter are exposed, but the amount of damage done is so small, that little is said about this form of spoilage. The remedy generally consists in keeping out the rays of light, using containers other than glass, and where the latter is the only convenient receptacle, tinted or dark-colored glass must be used. Water vapor coming from the humidity in the atmosphere hastens the decomposition of dried or dehydrated foods. High humidity will increase the spoilage of most all foods. Products that are injured by humid air should not be placed in cold storage without the protection of tightly covered or even hermetically sealed containers.

Other Preservation Methods

In a general way, cold and the temperature of storage have been mentioned as having a marked effect on most all kinds of food spoilage. Nature's cold, however, has but a limited use and then usually on a small scale and for short periods of time, for the uncertainty of

weather conditions enhances the risk of spoilage. Artificial refrigeration made available anywhere at all times and even during transit has aided greatly in improving the health and happiness of all people. It is, however, important to mention at this time that there is a difference between the terms cold storage and refrigeration. The latter term is only used when freezing temperatures are employed. Cold storage is a general term and though it includes refrigeration, the temperature at which food is placed in cold storage varies and depends upon the nature of each product. Foods are well preserved by cold if placed in storage in the best condition, and kept at the lowest temperature that is not physically destructive to such food. It is on this account that in cold storage, different foods require different temperatures. Many varieties of fresh fruits will keep almost five times as long in the cold as compared with keeping qualities at room temperature, but some fruits and certain classes of foods cannot be kept for long periods of time at low temperatures, for even here nature's ripening process proceeds slowly. Other classes may even show decomposition over an extended period of time, particularly if the food was contaminated with micro-organisms, when first placed in storage. Altogether and from a broad standpoint, where efficient methods are used, artificial cold and refrigeration have proven to be a process of great benefit to mankind. The truth is that ice and refrigeration are vital agents required by modern civilization. If foods which are fit to eat when fresh, are stored in such sound condition at the proper low temperature and for the required length of time as may have been demonstrated by practical experience or experimentation, such foods will lose little of their flavor and the food values will remain practically unaltered. Do you realize that there is in constant use in this country during the year about 800,000,000 cubic feet of cold storage space? It is therefore unfortunate that prejudices exist against this method and even other efficient methods of food preservation. Such attitude is generally based on limited and unfortunate experiences, improper technique, or most frequently solely on ignorance.

We have been compelled to interrupt our picture, as we will at varying intervals from time to time, so that in expressing our thoughts and describing various parts in more detail we will understand, appreciate, and enjoy more fully the view.

DEHYDRATED FOODS

If we therefore return to the picture and review it again, we may observe that for untold centuries, other methods of preservation of food had been practiced. Other methods had to be employed so that food should be preserved, if possible, for longer periods of time, than could be possible by cold temperatures. Primitive man found that another means of adding to his food supply was by the drying process. The exact origin of this method is perhaps lost in antiquity. The Egyptians and Chinese undoubtedly practiced this process of preserving food. Figs, dates, dried grapes and raisins are mentioned in some of the oldest writings.

In this country, our picture shows the Indians drying meat and fish and some vegetables. The white man found the Indian using this method as a means of adding additional products to his meager food supply. The Colonists dried fruits and in fact established the food industry on a commercial basis when they began to dry codfish and market this product. It was perhaps not until the beginning of the Civil War that other desiccated foods were made available. Reports of these dehydrated products and especially dried vegetables are given in the army records.

It was not until after the Civil War that the dehydration of food on a commercial basis was extended to substances, other than fish. The fruit-drying industry on the Pacific Coast had its inception about this time.

The removal of water from foods by natural means, employing the beneficial effect of the sun, is perhaps the only method of the few practiced in those early days, which is used today almost unchanged, and even to a greater extent than ever dreamed of then. Many modern methods of drying by artificial means are also employed today, inasmuch as sun drying cannot be practiced on many foods; and where used on a commercial scale, it is only practical, providing there is a long dry season without rainfall or humidity. Drying or dehydration is an effective means of preserving foods, and is employed in almost all classes of foods. It reduces the bulk and thereby simplifies the storing, handling and distribution of food. The effectiveness of dehydration is due to the fact that micro-organisms causing spoilage cannot exert their effects in the absence of moisture or water. Drying, therefore, if properly carried out, is a specific remedy against decomposition by bacteria. If the latter are present or get in during packing, etc., and the dehydrated foods are brought in contact with moist-

ure from the humidity in the air or some other source, decomposition may set in. Care must therefore be taken to keep such foods dry by proper protective means. Drying does not yield a product which is protected against the possibility of attack by insect pests. In fact insects are attracted more easily by some dehydrated foods. It is, therefore, important to cover or protect such foods and otherwise guard against insect infestation. One of the severest criticisms against dried fruits is the statement that the cell structure of foods is changed during dehydration and that when water is added, the food is not brought back to its original condition. Though some marked changes in cell structure may be produced in the dehydration of some foods, the advantages of this method are so numerous that such criticism can be disregarded. On this account, however, the drying methods that are most satisfactory or more frequently used are those in which the water is removed without affecting the food value of the product, which is so treated for preservation. There are many mechanical processes and artificial means of drying. Blasts of hot dry air, furnaces, steam kettles, vacuum and other special types of machinery may be used. The most satisfactory methods are those in which the foods are dried under a perfect regulation of temperature, humidity and rate of airflow. The important dehydrated products on the market today are most fruits, especially those rich in sugar, some flesh foods, vegetables, dairy products as dried milk and eggs, cereals, nuts, sugars, starches, grains, individual or in combination with condiments, eggs, etc., and all kinds of extracts used in the home for beverage purposes. There are many countries that would have never been able to use cow's milk and other foods, if it were not for this process of dehydration. Some of the dried foods may not be used in large quantities in our homes, because the same product may be available in large enough quantities when fresh. But in communities where not available and in commercial industries, these dried preparations are widely used. This is especially true of dried eggs and dried milk, employed in the diet of all in countries where these are not found in the fresh state, and they are also used extensively by bakers and confectioners. With dehydrated products, it is possible to have a satisfying breakfast or any meal in but a few minutes anywhere and any time. But little space is required for a package of pancake flour, dried eggs, dried milk, coffee or other beverage, etc., and you can quickly prepare some delicious pancakes, fried eggs, your favorite beverage, followed by a most pleasing dessert made from a dehydrated product.

The removal of water from foods producing a dehydrated product may be at times only incidental, and again we may employ a combination of drying and other preserving methods, as in the case of smoking, a process which is a partial dehydration combined with chemical preservation. Our picture may show where the art of preserving food by contact with the fumes from smoldering wood may have been accidentally discovered by the ancients. It may have been found that meat, left hanging near the fire, acquired a more pleasing flavor and the important property of remaining fit for consumption by man for a long period of time after such exposure. There are records available to show that this method has been used for many centuries. A separate building or stack has replaced the old house chimney, making possible the intensifying of the smoke. The chemicals present in the smoke, acetic acid, acetone, so called "creosote" compounds, etc., not only collect on the surface of the food treated, but may penetrate into the latter. These chemicals, possessing definite preserving properties, prevent bacteria from growing and exerting their effects. A quick artificial but poor method of smoking flesh food is to dip or paint the latter with a solution of pyrolignic acid at various intervals. The meats, etc., are then allowed to dry. Smoking as a method of food preservation is used only upon flesh foods, due to the fact that the flavor imparted to the latter by the smoke would not be tolerated in foods other than fish or meat.

Smoking of fish or meats may be combined with a salt treatment, so-called salt curing, or other modifications may be practiced in some localities where a particular flavor is sought. Smoked foods cannot be depended upon to keep for long periods of time. Other methods, as refrigeration, etc., are necessary, if one wants to prolong the period of preservation. In fact, it may be important to mention at this time that all dehydrated foods, powdered milk or eggs, fruits or vegetables are greatly benefited and are preserved for longer periods of time, if stored at low temperatures.

STERILIZED FOODS

Sterilization or complete destruction of bacterial life by heat is another method, which, as a means of preservation, is not only used in the household, but is practiced on a large scale commercially. The importance of heat as an effective weapon against the spoilage of foods was made possible by the researches of Pasteur. He not only showed the relationship of micro-organisms to disease and the decay of organic matter, but he in-

troduced the process of Pasteurization or heat sterilization as a means of destroying these offenders. The term sterilization is still employed when heat is used as a means of destroying micro-organisms. The term Pasteurization is used commercially only when a limited heat treatment is employed, with the object of not necessarily killing all germ life, but mainly to kill or render innocuous those organisms that produce disease. This process, described really as a form of partial sterilization, produces very little change in the food value of the food so treated, and will usually destroy many types of organisms that may be present and hasten the decomposition of the food. In 1860-64, Pasteur employed this process of Pasteurization in his investigations, which saved the wine industry of France and at the same time opened up the new field of Bacteriology. In 1886, the chemist Soxhlet advised the use of heated milk for infants. In 1890, we find Pasteurization employed on an extensive scale in this country in the treatment of milk, preparing it for marketable purposes. The value of this process, which as a public health measure is compulsory today in most large cities, cannot be overestimated. This method is applied in practice by placing milk in coils, suitable vats or container, subjecting it to a temperature of 145 degrees F., holding the milk at this temperature for twenty minutes and then rapidly cooling. The milk is then refrigerated and disposed of within a few days.

If any food is placed in a container, the latter stoppered with cotton and this then subjected for a sufficient length of time under the influence of heat, employing boiling water, steam, etc., a thoroughly sterilized product will be produced. The food will remain preserved indefinitely, even though the air is free at all times to pass back and forth through the cotton stopper. The outside tufts of the latter act as a filter, so that the bacteria in the air on the outside are retained, and the air passes through as sterile air. As long as the stopper is not removed, the food will not decompose, even though the temperature and humidity may vary and become excessive. The heat employed will not only kill disease-producing bacteria, but bacteria that cause spoilage, insects and their eggs, that may have found their way in; and in fact most agents causing decomposition are destroyed or their activity is arrested. It is therefore apparent that this is a most valuable method of preserving food. It is of course impossible to market or ship foodstuffs in containers stoppered with cotton, so that different containers and methods of sealing these were introduced.

CANNED FOOD Glass, non-porous earthenware and metal cans, usually made of tin plate, are most advantageously used as food containers. The word can was employed as an abbreviation of "canister," for canisters of tin plate, fashioned by hand, were used in the early days as containers. The process of preserving can and contents became known as "canning" and the finished preparation was marketed as "canned goods." Cans of "tinned food," as the English use the term, are found the world over today. Foods which are rare or unknown, or never available in a natural or uncanned state in some places, are now possible, and are distributed there.

As agents assisting in preserving foods, containers may be divided into three classes. First, we have those that are hermetically sealed. A hermetically sealed container may be defined as one which is thoroughly sealed and will show no visible leakage when placed under water. The choice between tin-plate and glass containers is dependent on factors other than their efficiency in preserving foods by this process, as both classes of material are suitable as containers to be sealed hermetically. In sealing food by this method, it is almost impossible to prevent sealing a certain amount of air in a container. There are some foods which will spoil even with this small amount of air present. The result has been in addition to simple hermetic sealing, foods are also hermetically sealed in a partial vacuum (the air in the container being withdrawn before sealing), and we also have hermetic sealing with inert gases. Gas packing is usually carried out by withdrawing all the air and allowing the vacuum thus formed to be filled by some pure, inert gas from a tank. The gas is nitrogen or usually carbon dioxide, which has in itself an ability of restraining the growth of some organisms, that cause spoilage.

The second class of containers used in preserving foods are those in which we do not have an absolute hermetic sealing. The latter is sacrificed to ease of opening. The lids, tops or covers are usually "screw tops" or "slip covers," etc. Containers sealed in this manner are inferior to hermetically sealed containers as aids in the preservation of the food present. They are therefore used only for foods, which do not require drastic means of preservation.

The third class of containers are those in which no attempt is made to have the lid airtight. As a container, it is merely better than paper or porous material and protects the contents from excessively dry or humid air.

The preservation of foods by placing them in hermetically sealed containers and then subjecting them to the action of heat to destroy the agents causing spoilage was introduced by Appert, a French confectioner, in the early part of the nineteenth century. Though claims are made that Saddington, an Englishman, prepared foods by a similar method, Appert is considered the discoverer of this process, as records show that in 1810 he was granted patent rights on his process. Though practiced on a small scale, Appert's method was adopted and used not only in France but in England and other countries. In this country, Appert's method was introduced by William Underwood in 1821, and later in 1839 by Isaac Winslow. Only glass containers were used in the early days. The use of tin cans, or the beginning of canning as we know it today, was started by Pierre Angilbert in 1823. It was years later that the process was employed on a commercial scale. In 1839, Wright of Baltimore, packed oysters, and Treat of Eastport, Maine, packed salmon by this process.

Appert's method is practically the same procedure the housewife employs in the home in putting up vegetables, fruits, etc. With but little modification, the same process is employed commercially. You remember the process. You gather or buy the fruit or food, and then prepare them for cooking. They must be washed, hulled, or peeled, and in case of some fruit the stones are removed. These are then boiled—with or without sugar, as the case may be—care being taken to see that the fruit or the syrup does not burn. The jars or containers are washed well and heated in boiling water. They are then drained, the cooked food is poured in steaming hot and the top is fastened tight. The containers are then turned upside down, and after a few minutes, if leaks are not observed, the canned food is stored in a cool, dark place until needed. On a large scale, the finished product is usually placed in boiling water or under the influence of steam for a designated length of time as an additional precautionary measure, as this serves to sterilize the canned product. For better results, fractional sterilization should be used. In this method, the containers are given a second and even a third heating after intervals of twenty-four hours.

It is unfortunate that the average individual is prejudiced against all canned food except those put up at home. Possibly this is due to the fact that until recently, manufacturers refused to allow visitors through their factories. The real reason was that each manufacturer regarded his process as a secret, and the precautionary measure of no

visitors was taken to guard against the disclosure of his secret. On this account, rumors were heard that foods were handled in an unclean or careless manner at commercial plants.

The truth of the matter is that one wonders that the commercial development of canned foods survived at all, after one reads of the many failures and much spoilage in the old days. The outbreak of the Civil War opened a large market for canned foods. Defects were perhaps not noticed by the armies, as they would have been by housewives. Even if "swelled" cans were found, which contained foods that were far from desirable, complaints were useless and in days of war, poor food is looked upon by the hungry soldier as better than none. There is no doubt, however, that this condition developed a certain stigma to canned goods, so that it has taken over a half century to overcome it. On the other hand, the manufacturers were taught by this experience. You must also remember that Pasteur's epoch-making series of investigations were being carried on during the early sixties or about the same time that the war was on. Germs, methods of sterilization, effects of heat on tin containers, and other important data were not known, and until these facts were found out, it was impossible for any industry, requiring the answers to these questions, to make rapid advances.

The first improvement, which in reality gave an assurance that canning could be regarded as an established commercial process for treating foods on a large scale, was the introduction of steam under pressure as a means of sterilization. In the early seventies, it was found that sterilization could be made more effective and even accomplished in a shorter period of time, if the canned material was placed in strong iron chambers and subjected to the action of flowing steam under pressure. The rise of Bacteriology and Chemistry has made it possible to investigate all phases of this industry in a thorough manner. Science has replaced guesswork. Exact knowledge is taking the place of superstition and ignorance. Revolutionary changes in the manufacture and sealing of cans and other containers have taken place, so that mechanical perfection with scientific knowledge and control have brought the canning industry to an unassailable position, and a necessary and even indispensable adjunct to the other methods employed in the conservation of foods.

The canner of today can put up a product which in many ways is more satisfactory, than that which we can have put up at home. In the first place, only the best food is chosen after it is grown under his

supervision in the most modern scientific way. The canning factory is usually located in the district where the produce is grown, so that as little time as possible is allowed for spoilage of the food during transit. Upon arrival, the food is again sorted and sent to the cleaning machines. From here on, humans do not handle the food until after it is packed and sealed. Automatic machinery, which can be cleansed and sterilized by modern methods, lessens the possibility of contamination. Methods of sterilization are more exacting than those used in the home. Thorough inspection throughout the entire process will detect any missteps and leaks, so that the can and its contents will be rejected before it is sent out on market.

There are very few foods that cannot be canned. Wherever other cheaper or more convenient methods are not applicable, hermetic sealing is being used. Meats, fish, fruits and vegetables of all kinds, cereals, poultry, dairy products, soups, puddings, syrups, and all classes of food reach the consumer in canned form. When you think of the condensed soups and other combinations of foods in cans, where you may have 10, 20, 30, and even more ingredients, composed of vegetables, herbs, condiments and spices, diluted with beef or chicken broth, do you not appreciate the helpfulness of these products? Canning makes possible a variety of food all the year round, a variety which can be stored in cans during the time of the year when the particular food is plentiful, so that in reality the canned product also conserves what would otherwise spoil and go to waste. Their convenience and economy, their small bulk as compared to that of the raw products employed in making the finished preparation, and the fact that they are available anywhere, any time, are facts which make it necessary that canning must be considered in any study of human welfare, and be regarded as a boon to mankind, and an aid to the health of humans.

It may be unwise to give a general statement as to the keeping qualities of canned foods. At times the particular food in question must be considered individually. One may, however, state that foods, heat sterilized and hermetically sealed by our modern methods, will withstand spoilage for a reasonable length of time. Where convenient, refrigeration should be used, as this will prolong the period of preservation. As a method of preservation, the canning method is the most satisfactory of all methods.

The housewife frequently objects to cans, due to the corrosion or blackening of the can, and subsequent solution or suspension of the

tin or iron, or the transference of the black residue in the food. At times, there may even be an actual perforation of the can. The causes of these disorders have been investigated and are known today. Various remedies have lessened their occurrence. In some cases, more care in the technique, especially in the removal of oxygen, has remedied the situation. Cans lined with enamel, paper, gum, resin and other materials are also used. The reactions causing such damage usually require a long period of time, so that the contents of most canned goods are probably consumed, before any marked damage is apparent.

We may also hear occasionally from some sources, that the canned foods lack some of the necessary food accessories, and that some of the vitamins are destroyed during sterilization. As it is, these statements will require a considerable more amount of experimentation before they will be accepted as final. Most vitamins, present in acid mediums, are usually not affected by heating for the period of time as practiced during canning. Fruits, vegetables, etc., are acid and this statement applies to such foods when they are processed in canning. Practical evidence has, however, demonstrated that canned foods occupy a high place as nutrients for humans.

It would require days of continuous filming to attempt to show you the picture as we see it today, and the role preservation plays in the production of modern foods for the market. We can picture a steer, a hog or other animal, and follow him from his home pasture to the table, where he is introduced as a preserved food. Have you any idea of the variety of frozen, pickled, cured, or canned meats and their combinations that are available on the market? In like manner, pictures of fruits, vegetables and all products starting in with the crude or raw product and following them on through until they are placed on our tables as dehydrated, canned or other preserved types would not only make a valuable study, but they would be an interesting showing of the part played by science today in food engineering. Can you picture the hundreds of industries, the thousands of plants, the millions of people and the billions of dollars connected with the marketing of food made available by preservation?

Our picture may even introduce foods that keep well for long periods by chemical preservatives, chemicals which today are rather notorious and not allowed by most authorities as food preservatives. Before mention is made of the latter, for they are used in certain quarters, I will direct your attention to other chemicals which are harmless,

or even have food value, and are employed as permissible preservatives. These are salt, sugar, vinegar, and lactic acid, very frequently found as constituents in our diet, and on this account perhaps rarely thought of as chemical preservatives.

CHEMICAL PRESERVATIVES

All sugars employed for sweetening foods, or even for their energy producing value, possess marked preservative properties, when used in sufficient quantities. Although cane sugar is most frequently employed, invert sugar as found in honey, glucose as found in many of the fruit juices, or any of the other sugars can be used. They will preserve any food, whether of animal or plant origin. But inasmuch, as we have to satisfy our taste, and the flavor and other aesthetic considerations play an important part, the use of sugars as preservatives is limited to certain foods of plant origin, especially the fruit class of foods. If a small degree of heat is used in the finished preparation containing the sugar, the yeasts and molds are generally killed. The food then placed in sterilized, tightly sealed containers will keep almost indefinitely. This is the basis of preservation used in the home and in industries, and in the production of jellies, jams, marmalades, preserves, candied and glaced fruits. In combination with berries and other crushed fruits, which are usually stored in the cold, there is also made available preparations of value in the ice cream, soda fountain supply, confectioners and baking industries.

In the preservation of milk, cane sugar finds a very extensive application in the production of the "condensed milk" on the market. This process was first tried by Newton in England in 1835. As an article of commerce, condensed milk dates back from 1856. The technique employed in preparing condensed milk is almost identical with that used in preparing jellies, etc. The milk is heated, poured into suitable vacuum pans, about 10 per cent. of cane sugar is added and the mixture is allowed to evaporate slowly at a low heat, until it is reduced to about one-quarter the original volume. It is then placed while hot in tin cans, and the latter are sealed. The yeasts and molds are generally killed by the heat treatment, while any other bacteria, if present, are prevented from multiplying or exerting their effect by the presence of the added sugar, present in the finished preparation in a concentration of approximately 40 per cent. to 42 per cent.

Canned milk, prepared in the same manner, but without added sugar (*i. e.,* unsweetened) is also prepared in large quantities and sold

as "Evaporated Milk." High temperatures must be employed in sterilizing the finished product, usually placed in cans, so as to be sure that all micro-organisms have been killed. As no sugar has been added to prevent the growth of bacteria that are present and usually not killed by the heat in the process of manufacture, drastic heat sterilization is necessary.

At present, most of the evaporated and condensed milk in this country requires about one and one-half billion gallons of fresh milk, the bulk of which would otherwise go to waste. With the additional amount of milk required for that food and delicacy made possible by cold preservation (ice cream), can you appreciate that the animal industry and farmers must keep a few million cows in good health, just for the production of ice cream and condensed milk products?

It is to be noted that sugars in high concentration do not kill micro-organisms. They merely prevent the latter from growing or exerting their effect. Hermetically sealing or refrigeration of products so treated will serve as an added protection, and prolong the period of preservation.

Salt, a food in itself, yet not used alone, but employed at almost every meal with other food, has acted efficiently as a preservative for centuries, and is used for this purpose today more extensively than ever. If salt is present in foods in concentrations of 6 per cent. and preferably 7 per cent. or more, most foods will keep from spoiling. Its use as a preservative in such strengths is however restricted to foods, which will not be objectionable when used at the table, because of the taste imparted by the added salt. The principal use of the latter will therefore be found as a preservative in flesh foods, salad dressings, mustard, tomato products, catsup, chili sauces, and in the making of a brine, in which is placed olives and vegetables (especially tomatoes, cucumbers, cabbage, etc.) and other "pickle" and "relish" constituents.

Applying dry salt or a brine (solution containing from 20 per cent. to 25 per cent. of salt) to fresh meat or fish is referred to as "salt curing or salting." The dry method is more frequently used. Here, as the salt diffuses through the flesh, the water leaves the cells and coming to the surface, a natural brine is formed. Refrigeration will of course prolong the period of preservation of salt-cured meats or fish. For red meats, small quantities of saltpeter (potassium nitrate) are usually added. Though mainly used to bring out the red color, this chemical possesses slight antiseptic properties.

Cheese and butter have salt added to them, and its presence accounts to a great extent for the keeping qualities of these foods.

Another legitimate food preservative is vinegar. The active principle, acetic acid, is present in concentrations of from 3 per cent. to 6 per cent., and the preparation is generally marketed as cider, wine, malt, glucose or molasses vinegar. Any food product, containing acetic acid in strengths of 2½ per cent. or 3 per cent. or more, will keep almost indefinitely. Acetic acid and vinegar are primarily used in the process of pickling. Any vegetable food may be pickled and preserved by this process. The vegetables most commonly pickled are cucumbers, green tomatoes, peppers, onions, cabbage and cauliflower. Fruits may also be preserved by vinegar, but the pickling of this class of foods is not frequently attempted. However, mention might be made of the melon, which in Europe is pickled, and is a favorite dish. In some quarters, only the rind of the melon is pickled, and those of you who have tasted it know that it makes an excellent preserve. The term "pickling," as commonly used, refers to the preservation of food in solutions of salt, vinegar, or weak acids or other similar legitimate antiseptics, which may contain sugar and spices.

Vinegar, though feasible as a preservative for meats and fish, has never attained a wide use, and commercially it is only employed to a limited extent for this purpose. The only other food preparations, where vinegar may be employed conveniently as a preservative, are in salads, mustard, chili sauce and tomato products, where the high vinegar content (necessary to give a 2½ per cent. or 3 per cent. acetic acid preparation) would not be objectionable, because of the taste.

Just as the sugar glucose (present in fruit juices or formed from cane sugar) will produce alcohol, and, the latter after fermentation will yield acetic acid, so lactose or the sugar present in milk will yield an acid, lactic acid, after fermentation. In fact, when milk sours, this acid is produced. It is the acid present in most types of buttermilk, and due to its presence, such buttermilk remains naturally preserved. Lactic acid in concentrations of 1 per cent. or more has recently been found effective as a preservative in salads, egg preparations, etc. Like vinegar, it is harmless, and is to be regarded as a legitimate food preservative, having the advantages of possessing a more pleasing odor and taste. In all likelihood, we will hear more and more of lactic acid as an ingredient in our preserves and food products, as soon as scientific experimentation will give us more definite information than is available.

Some spices and certain fragrant herbs used for seasoning foods possess marked preservative properties. Cloves, due to the oil present is particularly effective, and is used for this property in combination with salt, vinegar or sugar in many of the dressings, catsup, sauces, etc. This spice, cinnamon, and others are legitimate condiments, which possess some antiseptic properties, and when present in foods prolong somewhat the period of preservation.

You have undoubtedly gathered by now the fact that the proper preservation involves not only the art of keeping foods fresh, so that they may possess their pleasing odor and taste, but that their nutritive value should remain unchanged, and nothing of an injurious character should develop or be produced during the period of preservation. All methods of preservation that have been considered thus far do not markedly affect the food or its nutritive property, and will not result in the introduction of added substances that may become injurious to man.

The simplest and cheapest way to preserve any food is to add a chemical preservative or antiseptic, which will retard the growth and development of bacteria. The term chemical preservative, as used here, is a chemical or drug not obtained from natural sources, which will not only retard the growth of micro-organisms, but may exert harmful effects when taken internally. This definition is given so as to differentiate such chemical preservatives from the natural, harmless and even useful preservatives, which are used as condiments, and act in the same way as the others. These are sugar, salt, vinegar, lactic acid, etc.

Prejudice against methods of preservation is due not only to ignorance, but also to the promiscuous, indifferent, and blind use of chemical antiseptics, without regard for the harmful effect to the consumer. Furthermore, food handlers, who are interested more in the immediate pecuniary consideration and not in the permanency of their business or in the health of the community, are apt to be too liberal in the use of such substances. What is more important is the fact, that these same chemical preservatives may be used to preserve foods, which were prepared from materials that are so decayed or spoiled, that such ingredients would never have been fit for consumption either due to their possible harmful effects or what is more likely, to the aesthetics involved.

There exists a general prejudice against the employment of any of these chemicals which may be truly classified as drugs. This is

rightfully so, not only for the reasons mentioned, but for the following objections which are raised:

(1) That if these drugs, even in small quantities are present in all foods, their accumulation may exercise a toxic effect on the system of the consumer.

(2) They may retard or disturb the proper functioning of the digestive processes and burden the waste eliminating organs of the body.

(3) To repeat again—some foods may have already undergone decomposition before the addition of the antiseptic. Such decomposition will thus not be apparent, while the food product itself, when consumed, will be unwholesome, even though the antiseptic is present.

The advocates of chemical preservation claim that the amounts of chemical employed are too small to be detrimental to health, and such substances simplify preservation methods, thus making our food supply larger and cheaper. It is true that each chemical substance must be considered by itself, and in relation to the specific foodstuff for which it is used. No sweeping generalization is therefore advisable against preservation by all chemicals. There are therefore some instances where chemicals that have proven to be harmless may be added in small amounts in some classes of foods. Where these are employed in foods placed on the market, it is best that their use should be regulated by restrictive food laws. It will thus be possible to make inspection of such plants so as to be assured that decayed ingredients are not being used in preparing the finished product, and that other sanitary precautions are observed.

A general, wide and promiscuous use of chemicals for preservation should be prohibited by law, not only for the reasons mentioned, but for the fact that more desirable and wholly unobjectionable methods of preservation have increased in their effectiveness, so that we have safer processes, which today are very cheap and more easily controlled. Moreover, the taste and odor of foods so preserved frequently warn us of their spoilage.

Though chemical antiseptics are used commercially but rarely today as food preservatives, it might be advisable to consider the properties of those which have been brought forward as harmless or least harmful. Mention will also be made of those that are not permissible as preservative but used at times illegitimately, most frequently to hide the inferiority of the food product.

Nitrates—The nitrates, usually sodium or potassium nitrate or saltpeter, are used mainly in foods made of animal flesh. It is but a weak preservative, and it is used primarily for the property it possesses of retaining and accentuating the red color of meat. It is harmless in the quantities ordinarily employed usually, ¼ of 1 per cent. When used to make stale meat look fresh, a fraud has been committed, and it is so regarded by sanitarians.

Benzoates and Salicylates—These substances are more efficient as antiseptics than boric acid and borates. They are water soluble and usually employed in food preparations that are of an acid character, so that, after their addition, free Benzoic and Salicylic acids are produced. Salicylic acid is condemned as a food preservative, and the objection is unanimous and well founded. Sodium Benzoate used in acid food preparations, producing Benzoic acid, has been a storm center around which the question of chemical preservatives has raged. No one would advocate the promiscuous use of sodium benzoate in all foodstuffs. It should not be used in foods which are consumed in large quantities so that the intake of the chemical will eventually be large, as when permitted to be used in tomato and other soups, cider, soft drinks, etc. But when limited to amounts which should not exceed 0.1 per cent., and employed in such small amounts in foods, which are used in small portions at a time, and therefore kept over long periods of time, there can be no serious objection from the standpoint of health. In fact, there is an added economic gain of preserving catsup, chili sauce, relishes, concentrated syrups and soda fountain fruit juices, until these products are all consumed. The main objection which is raised and requires careful watch and control is, to be sure that one is not using this chemical to preserve a food preparation made of decayed or undesirable ingredients. It is for this reason that products that do not contain benzoates or other chemicals have a much larger sale than similar preparations containing preservatives. Even the layman has realized that the keeping qualities of the latter are indicative of the freshness of the ingredients and care observed during the manufacture.

Boric Acid and Borax—These substances have been used in strengths varying from 0.05 per cent. to 0.1 per cent. as a preservative for milk, butter and other dairy products, broken eggs (sold as frozen eggs to bakers and confectioners), all fish and meat prepara-

tions, canned fruits and vegetables and other foods. They are usually the important ingredients present in so-called "food or canning preservatives," advertised or sold to the laity to be used during canning. Their use as preservatives in marketable food preparations is forbidden by law in most countries.

Sulphites, Sulphurous Acid and Sulphur Dioxide—Sulphur when ignited yields sulphur dioxide gas. When in solution in water, the latter yields sulphurous acid. In the form of its salts, especially sodium and calcium acid sulphites, a chemical preservative is available, so that when used in acid food preparations as fruit juices, etc., sulphurous acid is produced. These chemicals used in strengths from 0.1 per cent. to 0.5 per cent. are used more frequently as frauds perhaps, than any other chemical preservative. In addition to killing bacteria, molds and insects, when applied to dried fruits, it bleaches the latter, improving the appearance of the product, and also enables the manufacturer to add excessive amounts of water to increase the weight. Meat and other foods are also given a better appearance of freshness, though these chemicals are seldom used in meat products. Fruits used for "glaceing" and "candying" may be preserved by this method. It is used in making clear candy due to the property of hardening glucose, which is employed.

These chemicals, though they do not cause immediate symptoms even when used for an extended period of time, are nevertheless harmful. They are dangerous preservatives to employ, and it is best to regulate against their use, as other more efficient methods are available to obtain the desired results.

Peroxides and Hypochlorites—Solution of Hydrogen Peroxide or the peroxides of various metals, as Calcium or Magnesium, and solutions of the organic soluble chloramines and the soluble inorganic hypochlorides (especially sodium and potassium) are very effective preservatives. In very weak dilutions they can be used in the home for the preservation of wines, fruit juices and even for milk. The only objection which prevents their use commercially for marketable food preparations is the general objection to all chemical preservatives, that of abuse in their application and promiscuous use.

Formaldehyde—A solution of Formaldehyde gas, sold under the name of "formalin" and "preservaline," has been extensively em-

ployed in bygone days as a preservative of milk. It has also been used in frozen eggs and other foods, in strengths varying from .002 per cent. to .01 per cent. This chemical, though very efficient as a preservative, is the most objectionable from the standpoint of health. Its use as a food preservative is condemned and forbidden.

It might be advisable to mention other methods of preservation which have but a limited use. At the same time, I will list a few problems in the conservation of food which are of great importance. In fact, the line of demarcation between those problems which are purely ones of preservation or purely conservation is not as clear-cut as might be expected.

Attempts have been made for almost twenty-five years to utilize electricity for the destruction of bacteria. Evidence gathered to date reveals the fact that this method can be employed for the destruction of bacteria in milk. The keeping quality of the latter is excellent, the food value improved, and at no time is there a cooked taste apparent, when electricity is used.

Investigations are being successfully conducted to determine the necessary elements entering into the food supply of plant and animal material employed by humans as foods. You are all familiar with the treatment of soil to which are added various substances so that the end result may be a richer and more nutritious environment for the growing of our crops. You know the care taken as to the diet which is employed in feeding chickens, cows, etc., so that these may be fit for supplying better food products. Even oysters and other fish are being supplied with proper elements under specific conditions, so that as in the other cases, we may not only add to the total amount of such food present, but materially lengthen the period during which these may be available as foods. The prolongation of the duration of life of foods, so that they may still be eatable and nutritious, is after all the main object of preservation, and if this can be effected by desirable aids other than the use of cold, heat, sealing or by using legitimate chemicals, no objection can be raised by anyone. In fact, there is but little effort expended in these other directions, so that we may have a bigger and better supply of such foods and available over a longer period of time.

The injection of solutions of chemicals into the tissues of plants to stimulate their growth or kill disease-producing organisms and inoculating these plants against deadly bacterial diseases may be advantageously employed shortly, if the experiments which are being

conducted prove as highly successful as preliminary reports reveal. There may be other means of adding to the existing food supply. This world of ours has survived all sorts of notions and doctrines in customs and in matters of every-day life. Its instincts concerning the well-being and prolongation of the life of each one of us is deep-seated. Yet there is no instinct which is of such definite concern as is the craving for food, a varied number of foods, and the desire to have them available just when we want them and at a reasonable cost. This all is made possible by the methods of preservation described here. It is an understanding of the underlying facts as mentioned, which will enable the layman to partake more freely of all classes of foods—foods which may be preserved by methods that some are prejudiced against, because they are ignorant of the facts. There may also be the contention that some preservation methods lead to standardization and that individual effort may be destroyed by a continual popularity of tinned foods, etc. These objections are, however, made by those who lack imagination and refuse to observe the conditions as they actually are.

The facts are that more and more humans are eating better food, and a variety of foods, that would be impossible if our modern methods of preservation were not available. Many of our vegetables, fruits, meats, etc., would never have met each other or be used in such large quantities, if not for the canning or other industries employing preservation techniques.

You are all familiar with the many tempting foods peculiar to some part of the country or to certain countries. Many of these special foods are made available to all by methods of preservation. It is not even drawing our imaginations too far by stating that if we learn to eat internationally, we may have more enjoyment and even form a foundation for a more permanent peace on this earth. If we were to indulge more frequently in favorite and special foreign foods, made available to us by preservation methods, could we not learn to know people better? And truthfully when visiting their lands, could we not enjoy more fully our sojourn and develop a more complete understanding between ourselves? How much easier would conversation lend itself to our diplomats and all, over a dinner table, where the food which is served is being enjoyed by everyone—food, which made available by our modern methods, we could have trained ourselves to enjoy, even for a short period of time, so as to merely complete our mission.

Preservation methods have made possible a service to humanity which has aided greatly in the progress of civilization, with the result that more economy, better health and greater happiness have beeen made available than in previous days.

There are far too many individuals who deplore the increasing part that machinery and science play in our lives. This is all wrong. Surely the thinking man and woman cannot agree with this contention. We must make machinery finer and science even better, so that by the intelligent use of these we will be enabled to make our lives better, longer, deeper and richer. We will thus have more time for more ideal duties and in particular for that most ideal of occupations—the cultivation of the mind and soul.

WHAT AND WHERE ARE THE STARS?

By George Rosengarten, Ph. D.
Department of Physics

THE WEIGHT OF THE EARTH is 6,000,000,000,000,000,000,000 tons. On the 197,000,000 square miles of its surface almost 2,000,000,000 of the genus homo live and die. We dig beneath the earth's crust and extract 1,350,000,000 tons of coal each year and along the miles of cable connecting our respective homes 20,000,000,000 telephone conversations take place in the United States during each revolution of the earth around the sun.

George Rosengarten, Ph. D.

The radio brings to our ears a message from distant lands at a speed of 186,000 miles a second, sufficient to encircle the earth almost eight times. These figures I trust will enable you to adjust your scale of space and time in order to appreciate what follows. I shall adopt the shorthand of the mathematician in writing such large numbers as will be necessary in our study of astronomy. A million will be written as 10^6 which represents the number 10 multiplied by itself six times. A billion will therefore be 10^9 and the weight of the earth as recorded above may be expressed as 6×10^{21} tons.

The stars have always engaged the attention of man and we ask the question, *"What and where are the stars?"* Turn your attention toward the north on a clear starlight night. There at a point about 40 degrees above the horizon is the north star Polaris. You must observe that the other stars appear to rotate slowly in a direction opposite to the hands of the clock. The axis of the earth if extended would pierce the sky not far from the north star and it is the rotation of the earth that produces this effect. Once every twenty-four hours the stars appear to make the complete circle of the sky.

The stars appear in groups and fantastic shapes have been produced in the mind of man. These groups or constellations were given names by the ancient Greeks and Romans. The great dipper, Ursa Major, and the little dipper, Ursa Minor, are familiar to all in the northern sky. The two pointers in the great dipper indicate the posi-

tion of Polaris which in turn occupies the end of the handle of the little dipper. To the other side of the north star is the constellation Cassiopeia appearing like a kite with waving tail. These constellations may be compared to the geographical subdivisions marked upon a map and have no importance other than to give the approximate location of a star. Many of the stars belonging to these constellations are too faint to be observed with the eye.

HOW MANY STARS DO WE OBSERVE?

The total number of stars visible to the unaided eye at any one time is about 3000 and if we consider in addition those visible to one living in the southern hemisphere the number will be increased to about 5000. The entire sky has been mapped and many of the stars have been named and numbered. With the aid of the telescope and the use of photography we have observed 1000 million stars and no doubt there are as many more that we have not observed because of their distance.

The stars appear to us in varying degrees of brightness. This difference may be due either to the size or the distance of the star. A very big star at great distance may be faint while a small star nearby may be very bright. About 21 stars have an apparent brightness of the first magnitude. A greater number of the second magnitude and so on to the twenty-first magnitude where the number reaches the millions. In the northern sky Vega and Capella, on the opposite sides of the north star and at about equal distances from it, hold the first rank.

In the evening during the month of December you will find if you turn toward the south the beautiful constellation of Orion rising in the east and gradually moving higher and higher in the sky and finally setting in the west some 12 hours later. Two first magnitude stars appear in this constellation, the red giant star Betelguese toward the north and the star named Rigel toward the south. About this group of stars the ancients drew the fantastic figure of a giant with mighty sword and girded with the lion's skin, the three stars near the center forming his belt, Sirius, the brightest star in the heavens, also called the dog star, follows him in his nightly passage across the sky while before him moves the bright star Aldebaran and the open cluster of the Pleiades.

Before continuing our observation of the stars let us turn our attention to the men who have distinguished themselves in the field of astronomy, probably the most ancient of the sciences. The Egyp-

tians and the Chinese cultivated the science of astronomy, observed the motion of the heavenly bodies and calculated the time of eclipses. Pythagoras, among the early Greeks, supposed the planets in their motion emitted sounds too melodious to affect the ears of mortal man. Plato and Aristotle, by their observations and writings, added to the progress of the science. It was from the genius of Hipparchus that astronomy acquired a more systematic form, since his catalogue contains the position of more than 1000 stars, one hundred years before the present era. Ptolemy (127-151 A. D.) placed the earth in a most important position in the center of the universe and had all the other heavenly bodies revolving about it. Not until the end of

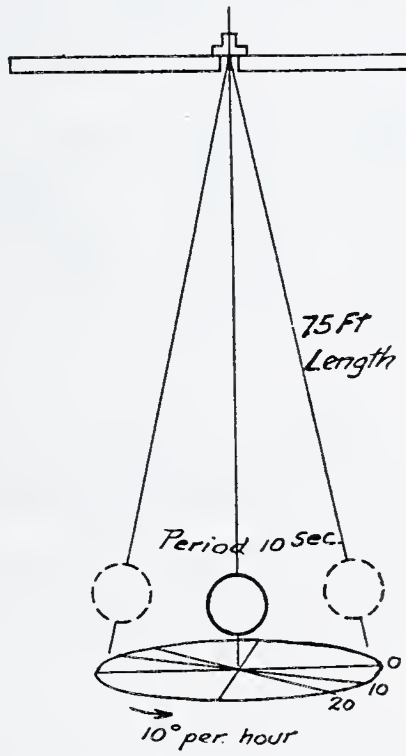


FIG. 1
The Pendulum.

the fifteenth century was the earth removed from this exalted place by Copernicus (1473-1543) when he explained the motions of the stars and the planets on the supposition that the sun occupied the center of the solar system and the earth and the planets revolved around the sun.

Whether the stars rotate about the pole star and the earth remains at rest or the stars remain at rest while the earth rotates was at one time a question of considerable controversy. In either case the apparent motion of the stars would be the same. To decide this question by experiment, Foucault in 1851 suspended a heavy iron ball by a wire 200 feet long from the dome of the Pantheon in Paris. This experiment the author has repeated in the elevator shaft of the

old College. From a rigid support at the top of the shaft was suspended a pendulum of 75 feet length carrying a ball of lead weighing 14 pounds at the lower end.

The ball was pulled aside and fastened to the side of the shaft by a cord and let stand over night so as to come absolutely to rest. To put the ball in motion the cord was burned and the pendulum started swinging in an arc of about 6 feet lengths, requiring 10 seconds to make the go and come. On several occasions the pendulum continued to oscillate for four hours during which time the earth was observed to rotate beneath the pendulum 10 degrees each hour or a total of 40 degrees. Because of the great mass of this lead ball it continued to swing to and fro in a most stately manner, not changing its direction of motion in space, and giving a visual demonstration of the rotation of the earth.

Tycho Brahe and Kepler appear in the seventeenth century to have contributed much to the science of astronomy. From the detailed observations of Tycho Brahe, Kepler was able to formulate his three laws concerning the motion of the planets about the sun.

Kepler's Laws.

1. Each planet revolves in an elliptical orbit about the sun which occupies one of the foci.
2. The line joining the planet and the sun describes equal areas in equal times.
3. The squares of the periods of rotation are proportional to the cubes of the mean distance of the planet from the sun.

$$t^2 : T^2 :: d^3 : D^3$$

In explanation of the third law, if we consider T and D as the period of rotation and distance of the earth from the sun as unity then the period of the planet Jupiter which is five times as far from the sun as the earth will be found from the above formula to be 11 years.

$$t^2 : 1^2 :: 5^3 : 1^3$$
$$t^2 = 125$$
$$t = 11 + \text{ years.}$$

The invention of the telescope in the year 1600 by Lippershey of Magdeburg gave a new impetus to the science of astronomy. Galileo (1564-1642) built several telescopes and observed the moons of

Jupiter, the rings of Saturn and the spots on the sun. Newton, born the year Galileo died, formulated his universal law of gravitation which did much to explain the motions of the heavenly bodies. The falling stone, the flowing river, the motions of the earth and the moon were all assigned to the same cause, the attraction of one body for another.

THE REVOLVING PLANETS

Around the sun revolve the planets Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, and Neptune each in its respective orbit. On a clear night you can usually see one or more of these planets located in a narrow belt across the sky not far from the path in which the moon is observed to move. The fact that these bodies changed their position with respect to the other stars was soon discovered. Varying in size and brightness as well as distance from the sun, they are objects for consideration.

Mercury is too close to the sun to be a familiar object in the starry sky and can only be observed at times just after sunset. Venus is the brightest of the planets. Jupiter is the largest, about 500,000,000 miles away from us and the light which you see has been travelling through space for forty-five minutes. Jupiter has something on the earth since he is provided with nine moons. Saturn has the peculiarity of being surrounded by a system of rings and is a most interesting object in a small telescope. Uranus and Neptune are so far away, about two and three billion miles respectively, that only the big telescopes can locate them.

These planets are not stars in the true sense, only bodies like the earth, shining by reflected light from the sun. A star is a body of matter which shines by its own light and will form the main subject of this lecture. Look at a photograph of the sky taken with a modern telescope and camera. The number of stars in the field of view is enormous but we must remember that they do not lie in a single plane, great distances exist between them in many cases. Detailed examination of the sky at the present time compared with observations made and catalogued by James Bradley in 1755 indicates that the stars are moving in two streams in opposite directions. Entire groups of stars move as a unit showing some connection between them but in all cases the distance to the star is so great that the displacement even in a few hundred years is exceedingly small.

Examination of photographs of the same portion of the sky taken a number of years apart show that many of the stars are double,

consist of two stars in mutal rotation about a common center. Thousands of such double stars were observed by William Herschel and his son John in the early nineteenth century and many more have since been discovered. Beside the stars, which appear as brilliant points, we find scattered about large masses of nebulous matter, many of which appear as gigantic spirals with large masses of matter about to be cast off, perhaps a new star in the making. It was from observations of this kind that Laplace was led to announce his hypothesis concerning the formation of the solar system in which he assumed an enormous mass of gas in rotation throwing off successive rings which condensed to form the planets.

Let us visit the Yerkes Observatory at Lake Geneva, Wisconsin, where we shall find the largest refracting telescope in the world. A huge lens 40 inches in diameter gathers the light from the distant star and sends it down a tube 62 feet long, where it is examined by means of another lens in the eyepiece. Such a telescope will cost about one-half million dollars. In addition to the telescope, many accessories will be necessary, a suitable housing must be built, special machinery installed for rotating the dome or raising or lowering the floor, an accurate chronometer or time-recording device, the camera, the spectroscope and the library. Here the astronomer works while others sleep, and you ask "What is the use of all this?" The time of day, the geographical location of a place in latitude and longitude, the position of the ships at sea or in the air, each depend upon the accurate observation of the astronomer.

On the top of Mt. Wilson in California is another gigantic telescope constructed upon different principles; a mirror 100 inches in diameter instead of a lens is used to reflect the rays of light from the stars into the eye of the observer. Can you conceive of the construction of a winding road up the mountain side, giant auto trucks burdened with this monster glass mirror weighing four tons or more, the construction of the concrete foundation or the erection of the steel framework for this telescope, all in the search for truth!

THE BIG TELESCOPES

What have the big telescopes discovered concerning the universe of which we form so small a part? We shall turn the telescope first upon the sun, our nearest star, about 93,000,000 miles away. Here is a mass of matter 300,000 times that of the earth with a surface temperature of 6000 degrees centigrade, sufficient to convert iron and other metals into the gaseous condition. It is the radiant energy from the sun, traveling at the rate

of 186,000 miles a second, that heats the atmosphere and the surface layer of the earth, making possible the existence of life as we know it today. From time to time enormous sun spots 50,000 miles in diameter are observed to move slowly across the surface of the sun and appear to indicate the existence of violent storms upon the sun and to be connected in some way with the magnetic disturbances upon the earth.

THE ECLIPSE OF JANUARY, 1925

The moon at times passes between the earth and the sun, shutting off the supply of energy from the sun. The eclipse of January, 1925, was observed by a greater number of persons than any previous total eclipse. The path of totality passed over the New England States, and many persons, including the author, traveled to New Haven, where conditions were very favorable for observation of this remarkable phenomenon.

FIG. 2
Eclipse of Sun, January 24, 1925; five minute intervals.
Photo by George Rosengarten.

The place I had determined upon from which to make my observations is known as East Rock Park. I will try to give you a picture of the locality. Situated just outside the city of New Haven, this park lies upon an elevation of 400 feet above the surrounding country. Several thousand climbed the almost perpendicular sides of the cliff through snow and ice to view the show which would not return for one hundred years to this part of the earth. I reached the top at 8 A. M. and set up my camera ready to shoot.

A slight cloud passed over the face of the sun and I thought for a moment that the show would be a failure. At 8.15 A. M. I made my first exposure through a thick film so as to cut off most of the light of the sky. At each five-minute interval I again snapped the shutter of my camera showing the figure of the moon passing slowly across the face of the sun.

I was not the only photographic astronomer. Cameras were mounted to the right of me, cameras to the left of me, to say nothing of those behind me. It was with some difficulty that we kept the crowd from falling over the legs of our cameras. They thought we had a better view two feet closer to the sun.

At 9.55 A. M. I removed the first plate from the camera and made ready a second for the phase of totality which is the remarkable feature of a total eclipse and can be observed only by persons situated in a narrow belt over a relatively small portion of the earth. Upon the cloud directly below the sun at this time we could see a most beautiful

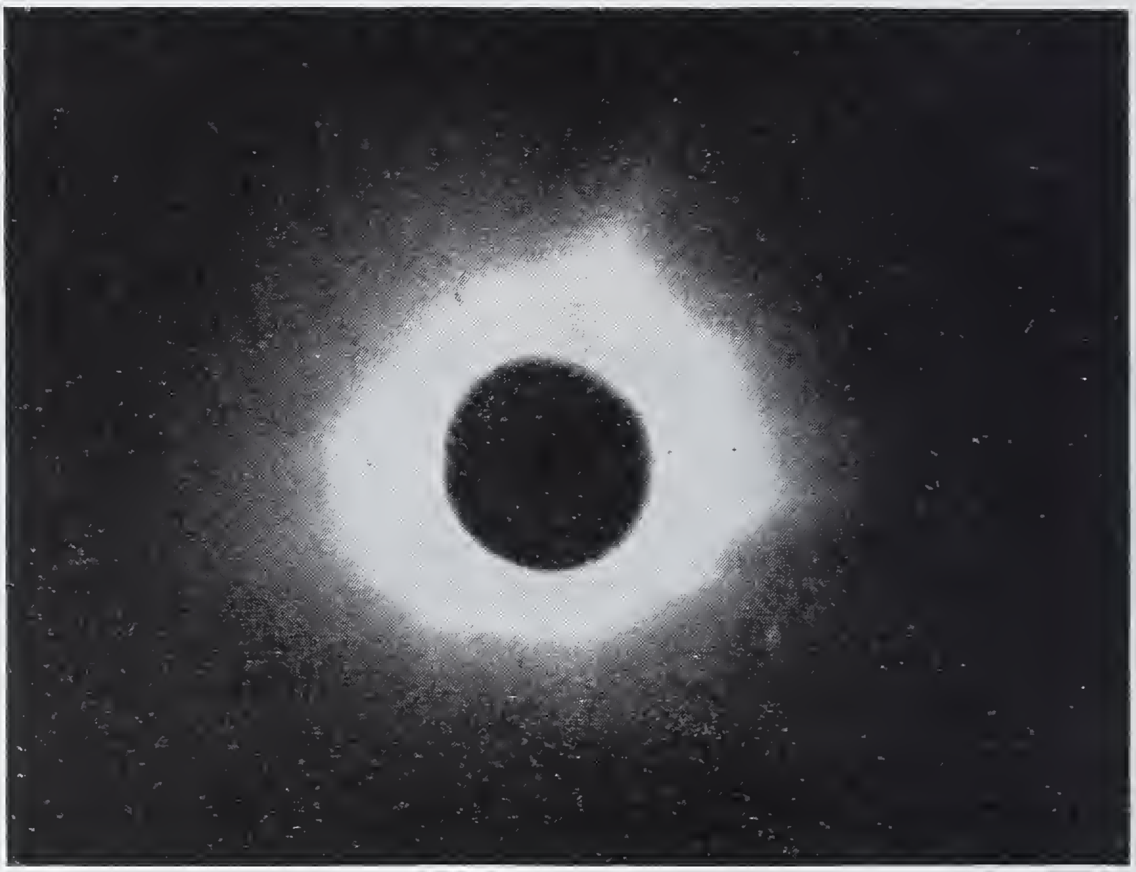


FIG. 3

Corona, January 24, 1925.

Photo by George Rosengarten.

rainbow, having the sun as the center. Gradually the sky became darker and the stars began to appear. At three minutes before totality there appeared upon the snow-covered ground the so-called shadow bands. They appeared as dark bands about 1 inch in width and 5 or 6 inches apart and traveled over the snow in the general direction of the wind. Darker and darker became the landscape. While we did not hear the hens calling, a nearby mill blew a long blast and we entered the phase of totality. In an instant the corona burst into view on a dark background. To the right two enormous streamers flared out for a distance of 1,000,000 miles. On the left one long streamer

made its appearance indicating the extent of the chromosphere about the sun.

Near the edge of the moon could be seen several flaming red prominences where some violent disturbance was at that time going on in the sun. To the right of the sun could be observed three of the planets—Venus at about three diameters from the sun, Mercury not so bright, just a little further to the right, and the planet Jupiter to the extreme right. It will be perhaps one thousand years before these three planets in their passage about the sun reach the same position again. Since the introduction of the photographic plate only forty-eight minutes have been available for making photographs of the total eclipse of the sun.

Why study this brilliant eclipse? Why travel to the uttermost parts of the earth to observe this phenomenon? I do not know. Why do anything? In the first place, our sun is perhaps typical of heavenly bodies called stars, and what we observe upon the sun takes place no doubt upon the most distant spheres. It must be remembered that the element helium was first discovered in the sun, only to be identified on the earth twenty-five years later. Today, as you all know, helium is the gas that is used to inflate the large airships, the means of transportation of the future, or should I say the present?

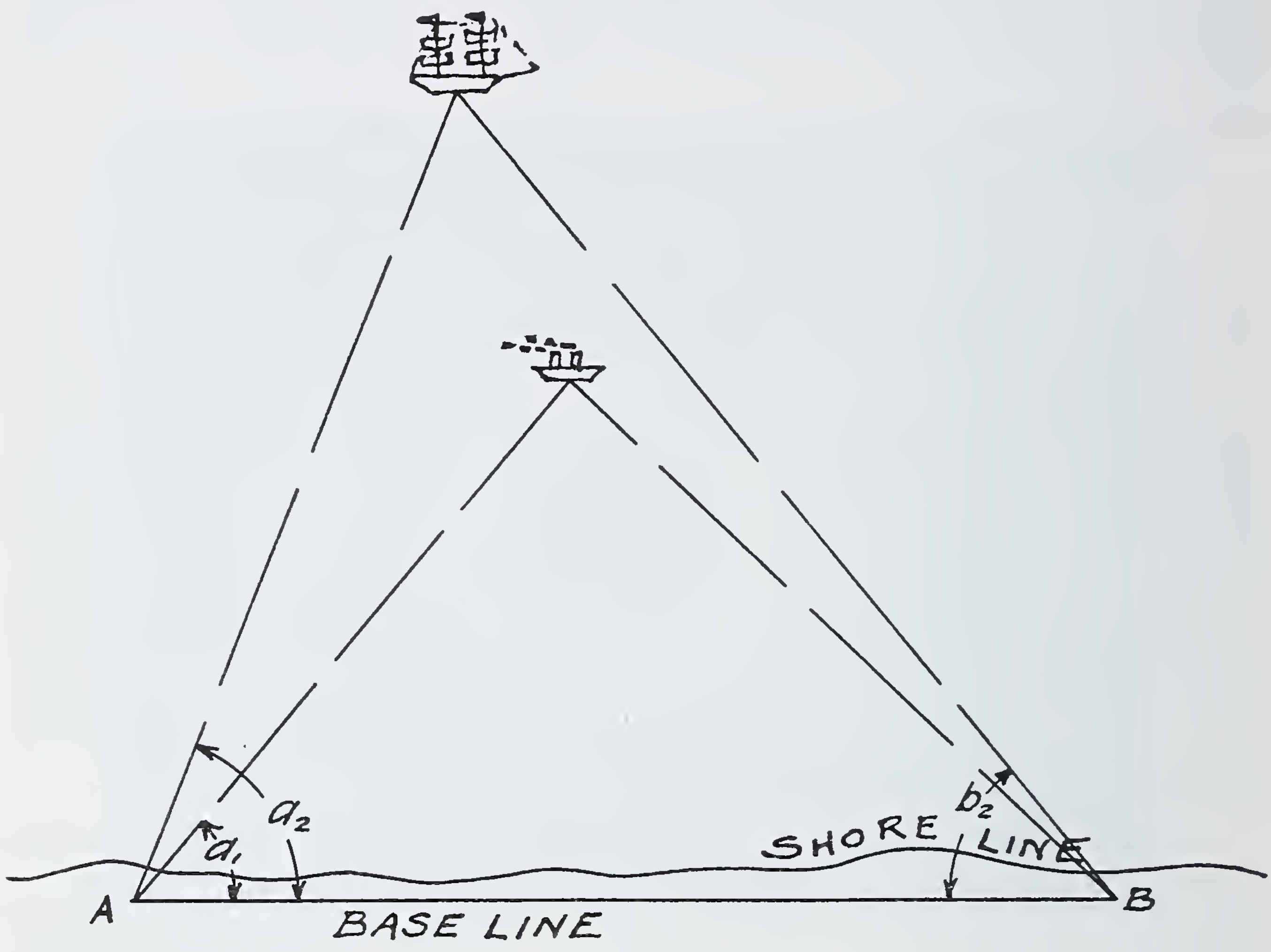
Just as gradually as the shadow of the moon shut out the light of the sun, so it passed on and the face of the sun again came into view. Two degrees below zero, my feet three-quarters frozen, but the eclipse safe in my bag, I departed for home.

The radiation from the sun each year amounts to 120 billion tons, and you ask "How long will this continue before the entire supply of energy is exhausted?" The mass of the sun is so great, about 200×10^{25} tons, that even though this radiation should continue without diminishing it would last many billion years.

The sun is an average star, comparatively near the earth, and affords an opportunity for learning much concerning the stars in general. In answer to the question, "What are the stars?" let us examine the light which the star emits with the spectroscope, which by means of a glass prism separates the light into its various constituents. If the light from the sun is passed through the spectroscope we find it separated into a brilliant band of color, the so-called visible spectrum, crossed by many dark lines.

If we perform in the laboratory the experiment of passing white light through the spectroscope we find this same band of color without

the dark lines. When the light rays are passed through the vapor of an element before entering the spectroscope we find the spectrum crossed by a series of dark lines depending upon the vapor used. The conclusion is that in the atmosphere about the sun the vapors of a number of the elements must exist. Iron, calcium, sodium, and hydrogen are the most prominent. It was by the use of the spectroscope that the element helium was first discovered in the sun. The spectrum of each element when observed with the spectroscope is charac-



DISTANCE TO A SHIP AT SEA.

FIG. 4

terized by a series of bright lines, due no doubt to the rotation of the electrons about the central nucleus of the atom. At the high temperature of 1,000,000 degrees and the enormous pressure existing in the stars these atoms become smashed and the degree to which this has taken place may be observed with the spectroscope. The motion of the source of light, the sun or star, causes a shift in the lines of the spectrum, the so-called Doppler effect, permitting us to determine that one star is rotating about another or traveling at great speed either

toward or away from us according as the lines are shifted to one side or the other.

"How far away are the stars?" How far away is a ship at sea? We shall examine the problem and determine the solution. If from the ends of an accurately measured base line we observe the direction of the ship relative to the base line we have a simple problem in geometry. The triangle so formed can be drawn to scale and the distance to the ship measured.

To find the distance to a star we must use the greatest base line possible which is the diameter of the orbit of the earth. Observations of the star made at the two extremes of this orbit six months apart will give the data necessary for the solution.

Suppose the angle at the star subtended by the diameter of the orbit of the earth is 1 second. In making the calculation we shall use only one-half of this angle, the so-called parallax of the star or the angle subtended by the distance from earth to sun. We may consider, with very little error, that the distance from the star to the earth is the radius of a huge circle in space and determine the circumference.

Circumference $= 2 \times 3.14 \times$ Radius.

A complete circle has an angle of 360 degrees or $360 \times 60 \times 60$ seconds.

If we divide the circumference of the circle by 1,296,000 seconds we will obtain the arc of the circle for an angle of 1 second, and since the angle at the star, in the case considered, is one-half second, we will multiply this result by ½. The length of this arc is the distance of the earth from the sun, which has been known for a long time to be of the order of magnitude of 93,000,000 miles.

The equation must be solved for the radius or distance to the star.

$$\frac{1}{2} \times \frac{2 \times 3.14 \times \text{Radius}}{1{,}296{,}000} = 93{,}000{,}000 \text{ miles}$$

$$\text{Radius} = \frac{93{,}000{,}000 \times 1{,}296{,}000}{3.14} = 38 \times 10^{12} \text{ miles}$$

Distances to the stars are frequently expressed in light years, that is, the distance that light will travel in one year. Taking the velocity of light to be 186,300 miles per second and multiplying by the number of seconds in a year we find that light will travel 5.88×10^{12} miles in one year.

By dividing the distance to the star by the value of a light year,

$$\frac{38 \times 10^{12}}{5.88 \times 10^{12}} = \text{approx. } 7 \text{ light years}$$

we determine that a star with a parallax of one-half second is at a distance of about 7 light years.

The giant red star Betelguese in the constellation of Orion has a parallax of .017 seconds and is at a distance of 191 light years. Betelguese is the largest star that has been measured, so large that if the sun were placed at its center with the earth revolving in its orbit all would be beneath the surface of this giant star. It is just a large mass of gas at high temperature with a density only 1/1000 that of the air. The light, you see tonight, left the star Betelguese before

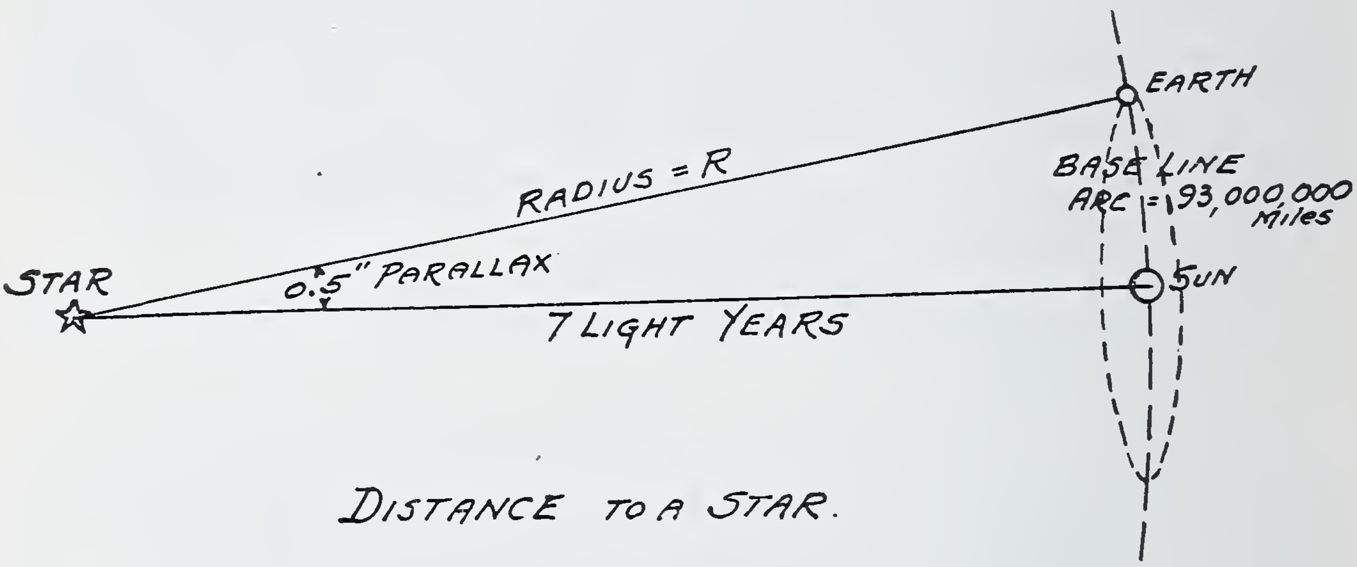


FIG. 5

the signing of the Declaration of Independence. Rigel, also a first magnitude star in Orion, is at a distance of 543 light years.

The stars of our galaxy appear to group themselves into a huge watch case form in the plane of the milky way. Looking out in this direction we see a much greater concentration of stars compared with the view at right angles to the milky way. While the dimensions of our galaxy are not definitely determined, recent investigation places the greatest diameter at about 20,000 light years.

Many of the stars vary in brightness. It may be that a star of the ninth or tenth magnitude suddenly shines forth with remarkable brilliance equal to that of a first magnitude star, lasts for a short time and then fades again to its former brightness or disappears altogether. Such a star is called a nova. What does it mean? Perhaps a collision. A catastrophe of this kind is possible but we need

have little fear considering the great distances between the stars such a thing is likely to happen only once in a million years. We are interested more particularly in the so-called periodic variables, stars whose brightness changes with regularity. The star Algol has a period of two days and twenty-one hours and sends us a peculiar dot and dash message which we have translated as follows.

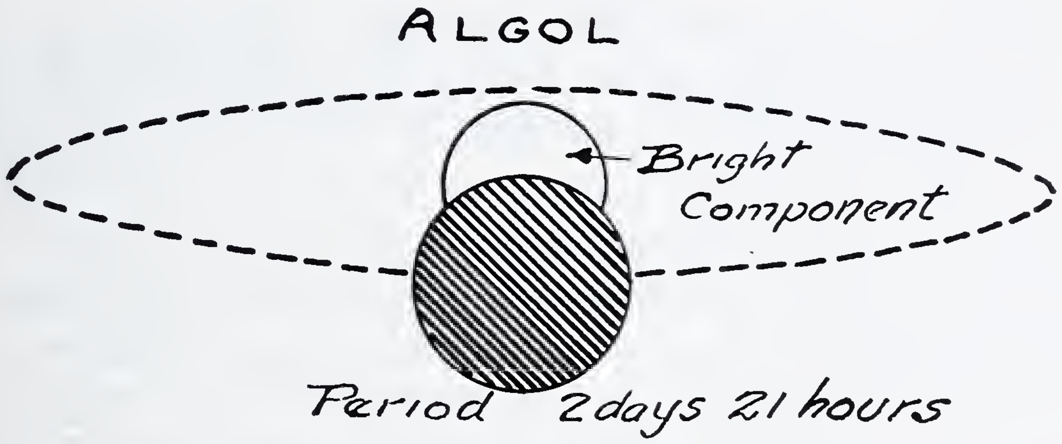


FIG. 6

I have stated that many of the stars are double, two stars rotating about a common center. In this case we are viewing the motion in a direction parallel to the plane of the orbit and at each rotation one star is eclipsed by the other. One of the components is brighter than the other causing a periodic change in the brightness as the fainter component passes in front of the brighter. This is the translation of the message that Algol sends. Thousands of these double stars have been discovered, their period of rotation determined and the masses of the components calculated from the law of gravitation. When such a system is viewed at right angles to the plane of the orbit one star is observed to revolve around the other with a period which may vary from a few months to 100 years depending upon the star.

Another group of stars called Cepheid variables, named after a typical star Delta Cepheid, send an entirely different message. In this case the brightness of the star increases very rapidly for a few days and then more gradually diminishes only to repeat these changes at periodic intervals of from 10 hours to 100 days. The reading of this message is not so easy, nevertheless a translation has been attempted and Professor Eddington states that these periodic changes may be due to the pulsating condition of the star, due to the expansion and contraction under the influence of gravitation and the elasticity of the star. Observations made upon the Cepheid variables

in the Magellanic star cloud in the southern sky have indicated that Cepheids of the same period have the same apparent brightness and since they are all at nearly the same distance must have the same absolute brightness. This is a remarkable discovery, for if it is true, we need only determine the period and the apparent brightness of a Cepheid anywhere and its absolute brightness and distance are at once known.

Let us see in what way this is possible. A 50-watt electric light at the other side of the room, twenty feet away, shines with an apparent brightness which if the light is removed to twice the distance will appear only one quarter as bright because it now sends its illumination over a spherical surface four times as great. Take the same 50-watt light 100 times as far away and it will appear only one ten-thousandth as bright. If the reasoning is reversed we observed two 50-watt lights, one very bright and the other only one ten-thousandth as bright, and our conclusion must be that the second light is much farther away; indeed it is 100 times as far away.

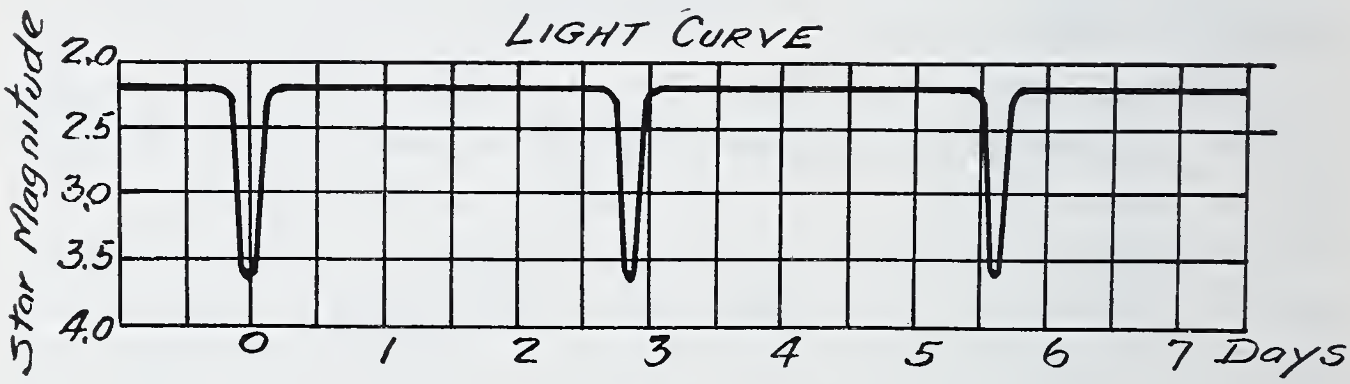


FIG. 7

In this way we have been able to determine the distance to the star clusters. Among the many thousands of stars which form a cluster we find a number of Cepheid variables whose period and apparent brightness may be determined. About eighty such clusters have been observed and their distances calculated to range from 20,000 to 200,000 light years. These distances almost stagger you and yet you ask is there anything still farther away. With a small field glass you can observe a faint patch of light not far from the constellation Cassiopeia, the kite-shaped figure I mentioned at the beginning of the lecture. When observed with the big telescope on Mount Wilson this patch of light appears to be a giant spiral nebula. In 1924 Professor Hubble discovered a number of Cepheids within this nebula and determined their period and apparent brightness. From

this data he calculated the distance to be of the order of 1,000,000 light years away, another universe entirely.

In summarizing, let me say that the stars of our galaxy consist of enormous masses of heated gas located at such distances that the light we see has been travelling for hundreds or thousands of years. Our sun is an average star and the elements found upon the earth turn up in these distant stars. Betelguese in the constellation of Orion is the largest star while Sirius is the brightest star. Outside our galaxy giant spiral nebulæ exist as island universes 1,000,000 light years away.

SUMAC AND POISON IVY

By Horatio C. Wood, Jr., M. D.

THERE IS AN ANCIENT LEGEND of the deadly Upas tree which exhaled an emanation so poisonous that it was death to sleep beneath its shade; even the birds of the air as they flew over it became paralyzed and fell into its branches, there to perish. While the stories of the ancients concerning the toxic powers of this tree are largely fabulous, there is in them this basis of fact, that the Upas tree is one of those plants that can poison by mere contact. A somewhat similar superstition, although not so poetically exaggerated as that of the Upas tree, clings around our common Poison Ivy. This famous—or should I say infamous?—shrub is not at all a relative of the true ivy but belongs to the interesting group of plants known to the botanists as the genus Rhus. Popularly they are called by the ancient Arabic name of Sumac, which in certain sections is corrupted to "Shoemake."

Horatio C. Wood, Jr., M. D.

THE SUMACS—TOXIC AND TONIC TOO

The sumacs, as a group, are mostly small trees or shrubs, some of them beautiful, some wicked and some only useful. Most of our native species are irregularly branched with compound leaves, generally lighter green below, and bearing large clusters of yellowish flowers. In the late summer the sumacs are brilliant spectacles along our Pennsylvania hillsides because of their bright scarlet berries borne in large, dense clusters. In the fall the leaves turn to a deep red and afford one of the most colorful bits of the autumn foliage. Although the wood of the sumac is too brittle to be of importance as lumber, in several species it is of a bright lemon-yellow color and beautifully grained; quite frequently it is used for the manufacture of small articles, especially of the sort that are sold as souvenirs at summer resorts.

In one or two species the berries are pleasantly acidulous and in certain parts of the world are used as food, especially in the form of jellies. Several species are strongly astringent and both the leaves and bark have been used for tanning leather both in Arabia and in

America; the fruit of one species is widely used in medicine for its astringency. Several of the sumacs yield coloring matter and are employed as dyes, either red, yellow or black. The most famous of the commercial products from this genus, however, is the resin used by the Chinese and Japanese in the manufacture of their famous lacquer-ware.

USEFUL SUMACS

GROUP I. (NON-POISONOUS)		
R. *coriara*	Mediterranean	Tanning and dyeing, edible fruit
R. *copallina*	North America	Red dye
R. *glabra*	American	Medicine, tanning, dyeing
R. *pentaphylla*	North Africa	Tanning, edible fruit
R. *typhina*	American	Tanning
R. *semialata*	Asia	"Chinese galls," tanning
GROUP II. (POISONOUS)		
R. *succedanea*	Asia	"Cera japonica" for candles
R. *vernicifera*	Asia	Lacquer
R. *toxicodendron*	North America	Black dye

Why is it that wickedness is so interesting? Our newspapers spread robbery and murder all over the front page, while art or science feels lucky if it gets a small paragraph in an obscure corner. As with the other things so with the Sumacs; the beautiful or useful we pass by with a word, the wicked is a topic for conversation. Of the seven species found in this country only two are poisonous, but they get five times as much attention as all their sisters combined.

WHERE THE POISON IVY THRIVES

The Poison Ivy, as it is usually called in this locality, known to the botanists as Rhus Toxicodendron, is to be found almost everywhere in sections of the United States where plants will grow. I have seen it in open fields and in the side yards of city houses, but it shows a marked preference for fence posts. Its instinct for fences seems almost animal-like. While it rejoices in the partial shade of a side hill or a big stump, it does not thrive in dense shade. It is a striking phenomenon on a cross-country hike to note the density of the patch of poison ivy which guards the entrance to many a woodlot and the suddenness with which it ceases when one has entered the forest. While it is by preference a vine, climbing up telegraph poles, tree trunks or fence posts, in the lack of such support it is content to grow as a low shrub. Its

dense foliage, varying from a vivid green to a bronze tint, and having a lustre almost as if varnished, makes it an attractive addition to many an ugly foreground. As far as I have seen them, the compound leaves are always trifoliate, but a five-leaved variety is said to be found in California. This threefold character of the leaf is the most ready distinction from the innocent Virginia Creeper (which has five leaflets) that, in habits and location of growth has tastes very similar. The trifoliate leaf also serves to distinguish it from the true Ivy, which, however, is not so commonly found on wooden fences, seeming to prefer to climb on stone. Some persons find the varnish-like appear-

Fig. I—Poison Ivy on an Old Stump. (Courtesy of Prof. J. W. Harshberger.)

ance of the leaf of the Poison Ivy to be the most ready distinction. The thing that my own eye notes the quickest is the extraordinary irregularity in the shape of the leaflets. Characteristically they are somewhat heart-shaped with smooth margins, but one will nearly always find some of them more or less toothed or lobed, often on one side like the thumb of a mitten.

The single native arboreal species of sumac which is poisonous is known as Poison Sumac or Swamp Sumac. It is fortunately much less common than the other members of the genus as it requires considerable skill to recognize readily. It is found nearly always in

marshy places or along the banks of streams; the harmless species which it most closely resembles prefers dry, open fields. Like all of the sumacs, its leaves turn a brilliant scarlet in the fall and make a tempting lure. The leaves are not easily distinguished from the upland and smooth sumacs, the most certain feature being the entire margins. The poisonous species of sumac—both the arboreal and the vineal—can be definitely recognized by the fact that the flowers and fruit are axillary, that is, borne in the fork of the leaf with the stem, whereas in the harmless they are terminal, at the end of the branches. They may also be distinguished by the character of the fruit; in the innocent sumacs the berries are in rather dense clusters and of a bright red color (whence the generic name of Rhus), while in the

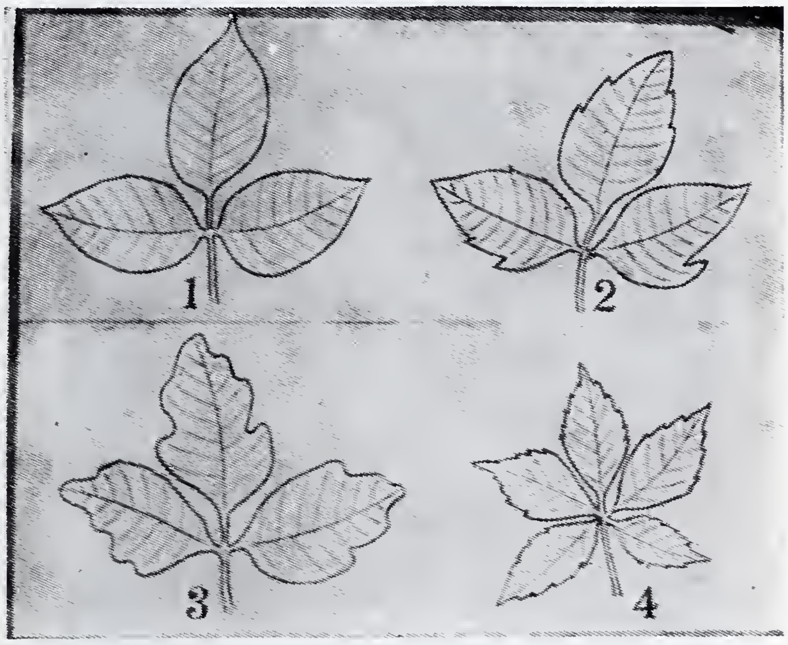


Fig. II—1, 2 and 3: Different Forms of Poison Ivy Leaves. 4: Leaf of Virginia Creeper.

poisonous there is a sparse cluster of dirty greenish-white berries about an inch in diameter.

FACTS AND FANCIES OF IVY POISONING

Many persons think they know something about ivy poisoning, but a remarkable thing is that despite a considerable amount of scientific study we have no definite knowledge of the nature of the poison, of its mode of conveyance nor of the best treatment. The popular belief is widespread that the poison is volatile and capable of being carried by the wind. To question this belief is almost like doubting the evidence of our senses; many are the persons who have been severely poisoned and are confident that they have not touched the plant. Yet all the scientific investigations which have been made seem to negative this idea. Mc-

Nair glued a leaf of poison ivy on the inside of a watch crystal and fastened this crystal to the arm of a person, known to be susceptible, in such a way that the leaf while within a fraction of an inch of the skin did not come in direct contact with it. It was left there for several hours but no irritation occurred. In another series of experiments Rost and Gilg blew a current of air by an electric fan through a bunch of foliage directly on the bare skin of a susceptible person for a long time without any ill effects. Youngken, who finds it hard, as I do, to deny all the stories of wind-borne infection, suggests that the hairs of the leaf, which he believes may contain some of the toxic

Fig. III—Staghorn Sumac. Note the Berry-Clusters at End of the Branches.

substance, might be broken off and carried by the wind. But there is no convincing evidence that the poison is found in these hairs and the experiments of Rost and Gilg seem to throw doubt on this theory. A much more probable explanation is found in the extraordinary toxicity and the ease with which it may be passed from one body to another. For example: A friend has been plucking leaves, you shake hands with him, some of the offending material may come off on your fingers which are later carried to the delicate skin of the face, which becomes inflamed. You are walking along the countryside and, knowingly or unwittingly, step on some poison ivy; when

you remove your shoes at night the poison can attach itself to your hand and be carried to various parts of the body. Croquet balls, garden implements, etc. have been shown to be responsible for the conveyance of the infection.

Various chemists have claimed to have separated the poison in a more or less pure state, but the present evidence is not sufficient to permit of positive decision between the conflicting claims. The two most widely respected are those of Pfaff, who believes it to be an irritant fixed oil—for which he suggests the name of Toxicodendrol—and of McNair, who found a non-volatile phenolic resin which

Fig. IV—Poison Ivy Leaves and Fruit.

he called Lobinol. An interesting observation of McNair's is that there is also present an oxidase which in the presence of the air gradually detoxicates the poison.

It is scarcely worth while to descant at length on the symptomatology of ivy poisoning, those who have it are likely to know it and those who do not are not much interested. There are, however, a few features of it which should be emphasized. The first of these is its distinct and marked contagiousness. Not only may it be spread from one person to another but also from one part of the body to another. A person who has handled some of the plant is likely to have the inflammation develop on the face—even without occurring

on the hands—because we are continually carrying our hands to our faces and the thinner skin of the face is much more susceptible. Generally speaking the irritation is more likely to occur and to be more severe on those parts of the body where the skin is thinner. For this reason the favorite seat on the hands is the area between the fingers, and the inner surface of the forearm is much more likely to be affected than the outer; in the face it is especially prone to be found around the eyes.

Another striking phenomenon is the variation in susceptibility between different persons and apparently of the same person at different times. Just how many people are susceptible is impossible to say, but my own feeling is strong that it is close to 100 per cent. of the population. In other words, I gravely doubt whether there is such a thing as complete immunity to it, although there is certainly a wide difference in the ease with which people get it.

FAVORITE REMEDIES

As regards the treatment of ivy poisoning I am sorry to say that I can not tell you any certain way to stop it. May I request, however, that if you know of any "sure cure" please do not tell me about it. You may be reasonably certain that your favorite remedy has been thoroughly tried and while it may have succeeded in your attack will fail in someone else. McNair in his monograph on the subject, lists nearly 100 remedies which have been recommended, many of them as certain specifics. Some of these are doubtless more or less useful; they may relieve the itching or shorten its duration, but none of them can be guaranteed to cure.

We may divide the remedies for ivy poison into two groups: those which simply aim to relieve the itching and burning and those which are employed with the idea of hastening the recovery. Of the symptom remedies I am inclined to believe that phenol is probably the most efficacious, but a strong solution of epsom salts has its proponents, and soaking in hot water will often assuage the uncomfortable sensations.

The drugs which have been suggested for curatives are in two groups: those which aim to remove the poison and those which are supposed to destroy it chemically. Among the former, the most important are soap and alcohol. These are both undoubtedly useful, especially to prevent infection after exposure. There is one danger that must be borne in mind in applying these remedies, and that is the

danger of spreading the irritant either over a larger area or to other parts of the body. The poison seems to be soluble in alcohol and if the latter be allowed to run over the affected surface to healthier areas of the skin, it will carry dissolved poison with it.

Among the remedies that have been suggested as chemical neutralizers, the most important are the salts of the heavy metals such as zinc, lead or iron, and various forms of sulphur. There is very strong evidence that the poison may unite with the heavy metals to form compounds which are insoluble and probably non-irritating. While lead acetate and zinc oxide both have their proponents, I am inclined to the opinion that ferric chloride is the best of this group. Of the sulphur compounds the sodium thiosulphate, the common "hypo" of the photographer, is the most used, but McNair has found the sodium sulphite more efficient.

"LIKE CURES LIKE"

Solomon is reputed to have been the author of the saying that "there is nothing new under the sun," and it is interesting to know that one of the most recent methods of treatment has been a tradition of the populace for hundreds of years. That is, the idea of developing a resistance to the poison. It is even asserted that the American Indian had evolved the idea of chewing the leaf to lessen susceptibility even before the advent of the "paleface" on this continent.

The modern craze for provoking immunity may be dated to the communications of Strickler, 1918, and Schamberg in 1919. The theory which is back of this method is very similar to that of the vaccines and similar bacterial products, namely, that from the introduction of small doses of the poison into the general system, the body acquires the power of neutralizing the poison and thus curing the local lesion. Schamberg, in his original paper, used the homœopathic tincture of Rhus tox., but in recent years various manufacturers have put out special preparations which are intended especially for hypodermic use. While there is a considerable body of clinical reports which seem to suggest that this method of treatment may have some efficacy—both as curative and as preventive—it is worthy of note that the only attempts, as far as I know, that have been made to measure scientifically the immunity conferred have failed to show any considerable degree of resistance. While one should not speak too dogmatically in view of the paucity of evidence, I confess that personally I have not been greatly impressed with the arguments of the advocates for this practice. It is interesting from the standpoint

of abstract science to note that up until now, only substances belonging to the group of proteins have been demonstrated to provoke the so-called immunity reactions in the body and there is no reason to believe that the toxic principle of this plant is a protein.

The following method of treating ivy poisoning probably holds forth as much likelihood of being useful, in the majority of cases as any. The part should be thoroughly washed with soap and water using a soft brush, such as a shaving brush, to work up a good lather. Care must be observed not to spread this lather to adjacent parts of the body because by so doing the poison may be carried with it. Some recommend washing the part with alcohol, but while this is efficacious there is much danger of spreading the poison. After washing, the part should be carefully dried with a soft piece of muslin or cotton, and then painted with a 5 per cent. solution of chloride of iron. The ordinary tincture of iron chloride diluted with two parts of water is about the right strength. This should be allowed to dry on the skin. If despite these precautions the skin becomes inflamed, a dilute solution of carbolic acid, about 2 per cent., is useful to relieve the itching and burning. The parts affected should not be exposed to sunlight and should be protected from the air as far as possible. McNair recommends strongly the covering of the affected parts with surgical paraffin to exclude the air. It is probable that the beneficent action of such resinous drugs as Grindelia is to be attributed to their protective properties. If blisters should form they should be punctured aseptically. It is very important to avoid scratching or breaking the blisters as either of these is likely to allow the entrance of bacteria into a skin whose resistance has been reduced and give rise to a new disease which may be more troublesome than the ivy poisoning.

LACQUERWARE The most interesting of the commercial products from the sumacs is the lacquerware. Genuine lacquerware is *sui generis;* it differs from everything else in the world. While it is often imitated, no other substance possesses all its valuable properties. We constantly coat metal or wood with a layer of resinous material for the purpose of beautifying it or protecting it against the elements, but the art of lacquering has little in common with the process of varnishing, either in purpose, method or product. When we varnish a chair, or a door, or a table, we regard the piece of furniture as a piece of wood, the varnish is simply an external finish. Lacquerware is often built up on a background of thin wood, but the wood

serves merely as a skeleton, the object is really made of lacquer. The art of lacquering appears to have originated, like so many of our useful or beautiful inventions, in the ancient kingdom of China, but has reached its highest development in Japan. The first evidence of a knowledge among the Japanese of the art dates to the latter part of the fourth century after their invasion of Korea, but it did not become of great importance till several centuries later. It reached its acme some time about the sixteenth century and after that entered into a period of more or less decline, but in recent years there has been an evident renaissance.

While modern chemistry has greatly improved the protective materials which are applied to wood under the name of varnish—and some manufacturers have even claimed that their product will with-

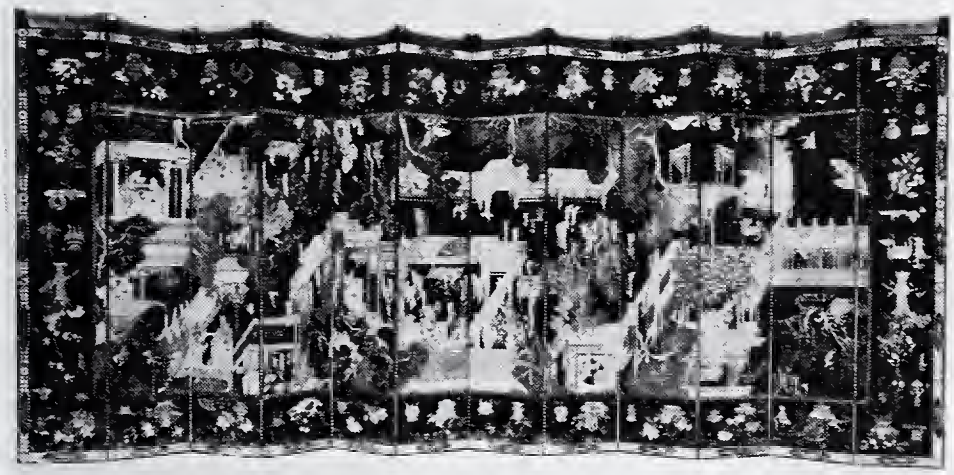


Fig. V—Chinese Lacquerware Screen in the Museum of the University of Pennsylvania.

stand boiling water—I know of none that will resist so many deleterious influences as does Sumac lacquer. Not only will it withstand the temperature of boiling water—and I may remark in passing that lacquer vessels are habitually used for soup bowls in Japan—but also hot alcoholic liquors, most acids, and even caustic alkalies. In 1878 a ship carrying the Japanese exhibit at the International Exhibit in Vienna sank in the Red Sea. When salvaged a year later the ancient lacquer pieces, brought to the surface and cleaned, still retained their original beauty and appeared in no way to have been affected by a year's submergence in salt water.

The permanence of lacquerware is partly due to the peculiar method of manufacturing, but probably in greater part to the chemical properties of the Sumac resin. Its manufacture has never been extensively practiced in either Europe or America and probably

never will. The Caucasian race lacks the patient persistence of the Mongolian, which is essential for the successful practice of this art. The whole process, from the collection of the sap to the final decoration with the artist's brush is one which requires tedious and skillful manual labor.

While it is probable that several species of the Genus Rhus contain in their sap more or less of the extraordinary resin, commercially it is derived almost entirely from the Rhus Vernix. This is a small tree rarely exceeding a height of thirty feet and closely related to our native poison sumac, and like it producing a resin which causes inflammations of the skin to those who touch it. Practically all those who are engaged in the lacquerware industry suffer at first from intense irritation of the skin, often associated with serious constitutional symptoms; after a while, however, they appear to develop an immunity. The resin, which is known in Japan by the name of *Urushi,* is largely produced in one or two northern provinces where the tree is extensively cultivated; in China it is limited largely to the province of Foo Chow.

The collection of the sap requires a considerable degree of dexterity and experience. The collector walks through a grove of trees armed with a sharp knife and a sort of spoon-like scraper. With the knife, after the removal of the external bark of the tree, he makes a series of transverse gashes through the bark and cambium layer, each cut being made with a single stroke of the knife, not deep enough to seriously injure the wood but so placed as to tap the largest possible number of resin canals. After so incising ten or fifteen trees he returns to the beginning of the group and with his spoon scrapes out from each cut the few drops of sap which have exuded. The sparsity of the yield and the consequent labor involved in collection may be gauged by the fact that a single tree bled to its death will rarely yield as much as two ounces of lac.

The juice as it first exudes is a grayish, milky liquid which, on exposure to air, rapidly becomes brownish and eventually almost black. It contains a gum closely related to, if not identical with, the arabin of Acacia, and a resin. The chief constituent of the latter is a resinous acid sometimes called "Lac-acid" but more frequently Urushic acid from the Japanese name. In the fresh state the resin does not differ materially in its physical properties from other vegetable exudates, but there is present also in the sap an enzyme which, in the presence of air, brings about an oxidation of the Urushic acid

into a compound not affected by caustic alkalies or by most of the usual solvents for resin.

The methods of treating the crude sap to prepare it for use in the lacquer art differ according to the specific purpose for which it is to be employed. Some thirty or forty different kinds of lacquer are recognized in the trade, each one fitted for some peculiar part which none of the others can play. In general the lacquers may be divided into two chief types, the transparent and the opaque. The latter have been mixed with various pigments, cinnabar for red, iron or charcoal for black, indigo for blue, and often powdered gold or other metals.

In the manufacture of lacquerware the artisan first makes a skeleton of the object—be it a box, bowl, fan or screen—out of thin board or paper mache. The next step, which is called "luting," is the application of a sort of filler made up of a mixture of lac and rice paste to fill up the cracks and knots and grain. After this is dry a sizing coat of lac is then applied and on this is fastened, with a special adhesive of lac and paste, a thin piece of muslin or similar textile. Over this is applied some seven or eight layers of different mixtures of lac, each coat being allowed to thoroughly harden and rubbed smooth before the next is applied. After one or two weeks of almost continuous labor, the article is ready for the market or may be turned over to an artist for decoration.

The decoration of lacquerware is not an industry but it is a fine art ranking with painting and sculpturing in its possibilities, yet differing from both. Some of the most famous artists that Japan has ever produced have not thought it beneath their dignity to work with the lacquer medium. Many thousands of dollars are not infrequently paid for a single lacquer picture.

We must not forget, however, that in Japan lacquerware is not merely the plaything of the rich, but has an important utilitarian rôle in the life of the poor. Cups and bowls, as well as fans and boxes, and a large variety of other objects, useful as well as ornamental, are made from it. To a large extent it takes the place of both metal and glassware in the domestic economy of the Japanese.

ICE—WET AND DRY

By Paul Q. Card, M. Sc.

Department of Industrial Chemistry

THE STORY OF ICE is both ancient and modern. Ages ago, certain weather conditions existed that allowed snow to accumulate in some areas faster than it could be melted by the sun's heat. The snow became compact. Ice layers were gradually added by hail, freezing rains, and more snow, until a mountain of ice resulted. Such a mass of ice is known today as a glacier. The glaciers did not remain stationary, but responded to certain influences, such as gravity and forces set up in the areas of formation. They moved in many directions, principally from the polar regions towards the equator, pushing objects along ahead of them or surmounting immovable objects and grinding them to the extent that the scars still remain visible today. There is evidence of glaciers having pushed themselves over mountains several thousand feet high.

Paul Q. Card, M. Sc.

MOUNTAINS OF ICE

The glacial periods of the earth have extended over a million years. During this period there have been several glaciations. They formed, existed many years, disappeared, and reformed again to disappear. The glacier is not entirely an ancient ice formation, for even today they envelop the island of Spitzbergen, and linger in the valleys of Norway, Sweden, Central Europe, and southern Asia. Then there are the great Columbian ice fields in the Canadian Rockies and many other nationally advertised glacial parks in North America. The Antarctic at the present time is covered with an ice field having an area about one-half that of North America.

When glaciers are close to the sea, as they are in the Polar regions, enormous pieces break off and are carried about by the ocean currents. These pieces are then known as icebergs. In the North Atlantic they travel southward, crossing the shipping lanes. They are a constant menace to maritime traffic and are responsible for many catastrophes at sea. It is the duty of the United States Coast Guard

Ice Patrol to locate them and radio the position, size, direction of travel, and rate of travel to the ships in the iceberg zone.

The bergs are sometimes quite large, extending as high as 500 feet into the air and a thousand feet or more either way horizontally. For every unit of volume of ice above the water there are 8.7 volumes below the surface. The estimated weight of some icebergs is around one million tons. Ships are always cautious in approaching an iceberg, for while it may appear to be a compact mass at the surface, sometimes there are ledges under water extending several hundred feet.

These silent terrors of the sea recognize no foe except destruction by heat in their wanderings. Bergs have been known to drift as far south as the northern approach to Bermuda. They gradually melt

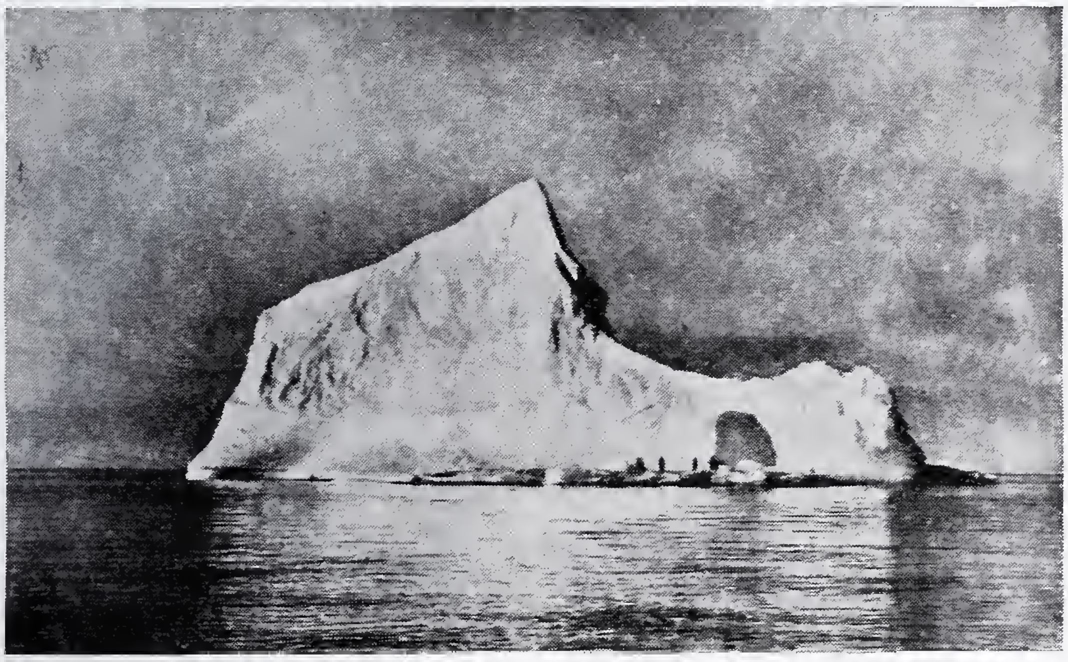


FIG. 1

Iceberg that remained within the sight of Donald B. MacMillan for two years.

Courtesy National Geographic.

when drifting into warmer water and may float along in unstable equilibrium. Here again is another danger to an approaching or even a passing ship. Bergs have been observed to turn over when the wash of a ship has disturbed them.

THERMITE AND THE ICEBERG

Icebergs have been disintegrated by igniting a mixture of iron oxide and powdered aluminum. The mixture, known as "thermite," was placed in a galvanized iron milk can and ignited on the berg. The reaction of burning thermite produces a temperature which varies between 2500 and 3500 degrees centigrade. The iron oxide is reduced to white-hot

metallic iron and the aluminum is changed to aluminum oxide. The heat rays emitted from the white-hot iron cause the ice to become honeycombed. This action is similar to the effect of the sun's rays on ice, the honeycombing being one of the first stages in disintegration.

Thermite is sometimes used to weld steel rails, and it is the same material that was used to break the ice jams that menaced several towns in Eastern Pennsylvania.

The phenomenon of ice formation is due to the loss of heat within a body of water. The means of heat escape may be by radiation or by conduction, or both. In the first case, by radiation, when the heat may be able to leave the water into a surrounding substance. The atmosphere is illustrative of this type of cooling. If a body of water, such as a lake, gives off more heat than it receives from the sun's rays, the temperature will gradually drop to such a point that it will change from a liquid to a solid.

FREEZING BY CONDUCTION

Freezing by conduction may be illustrated by referring to the manufacture of artificial ice, where the heat is carried away from the water by a brine bath surrounding the cans in which the ice is made.

During the cooling process, which takes place while the water is liquid, there is a contraction in the volume of liquid. The contraction in volume is similar to the contraction of nearly all other substances when cooled within certain limits. Thus water becomes more dense as the temperature approaches zero on the centigrade scale, which is the point where the liquid turns to a solid on further cooling.

Anders Selsius, a Swedish astronomer of the early eighteenth century, invented the temperature scale known as the centigrade scale. The freezing point of water was established as the zero point and the boiling point was taken to be 100. The distance on stem of the thermometer between these two points was then divided into one hundred parts, known as a degree.

The two points at which these physical changes take place were used in establishing two other temperature scales. On the Fahrenheit scale the freezing point is marked 32 degrees, while on the Réaumur scale it is O degrees. The boiling point of water on the Fahrenheit scale is 213 degrees, and on the Réaumur scale 80 degrees.

The commonest form of thermometer is the mercury capillary tube variety. Mercury expands approximately one five-thousandth part of its volume at O degrees C. for a degree rise in temperature.

Because of this very slight change in volume it is necessary to use a fine capillary so that the movement of mercury will be readily perceivable. Usually a longitudinal lens magnifies this very fine thread of mercury.

The mercury thermometer is replaced by the "spirit" thermometer in northern regions where the temperature is much below the freezing point of water. The "spirit" is usually colored so that the liquid can be seen without much difficulty.

The hydrogen constant volume method for determining temperatures has a considerable range. Changes of temperature are defined as being proportional to the corresponding changes of pressure in a constant mass of hydrogen confined at constant volume. The instrument is made of a bulb, containing a constant mass of pure hydrogen, and is connected to one leg of a manometer tube. This leg of the tube is marked to give a constant volume. The other leg of the tube is considerably larger and open. A scale on this tube indicates the pressure of mercury, supplied by an adjustable reservoir, necessary to keep the volume constant. The material used in construction of the bulb may vary according to the temperature to be employed. Glass, glazed porcelain, fused quartz, platinum and platinum-iridium have been used.

As our thermometers begin to drop and the cooling water becomes more dense, it reaches a point of maximum density, this point being 4 degrees C. On further cooling, the water begins to increase in volume and the density gradually increases until the temperature reaches O degrees C. At this point the temperature of the water will remain constant until 80 calories per gram of water are given up. The water then becomes solid. The specific gravity of water at 4 degrees C. is 0.999867 and specific gravity of ice at O degrees C. varies between 0.9159 and 0.9182, according to the mode of formation. When water reaches its maximum density and then expands on further cooling, it can be given as an illustration that 100 volumes of liquid at 4 degrees C. will become approximately 110 volumes of ice at O degrees C.

These changes in density explain the reason for ice floating on the surface of a lake or river. The water in a lake cools at the surface and becomes heavier to a slight depth. The heavy water sinks and is replaced by a warmer, less dense layer, which in turn cools. This cycle keeps up until all of the water in the lake reaches the temperature of maximum density of water. On further cooling, the lighter

water now floats and continues to be cooled until ice forms over the entire surface.

The rate of heat exchange becomes slower because ice is a poor conductor of heat. More ice is formed immediately under the first layer, building it up until it will support a considerable weight. In summarizing, the air above the lake will be below the freezing point of water; the ice will be frozen at a temperature of O degrees C. and gradually cooling to below zero, the water layer will vary from O degrees C. to 4 degrees C.

Ground ice or anchor ice is formed at the bottom of rapidly moving shallow streams when the water is thoroughly mixed and does not have a chance to settle in layers.

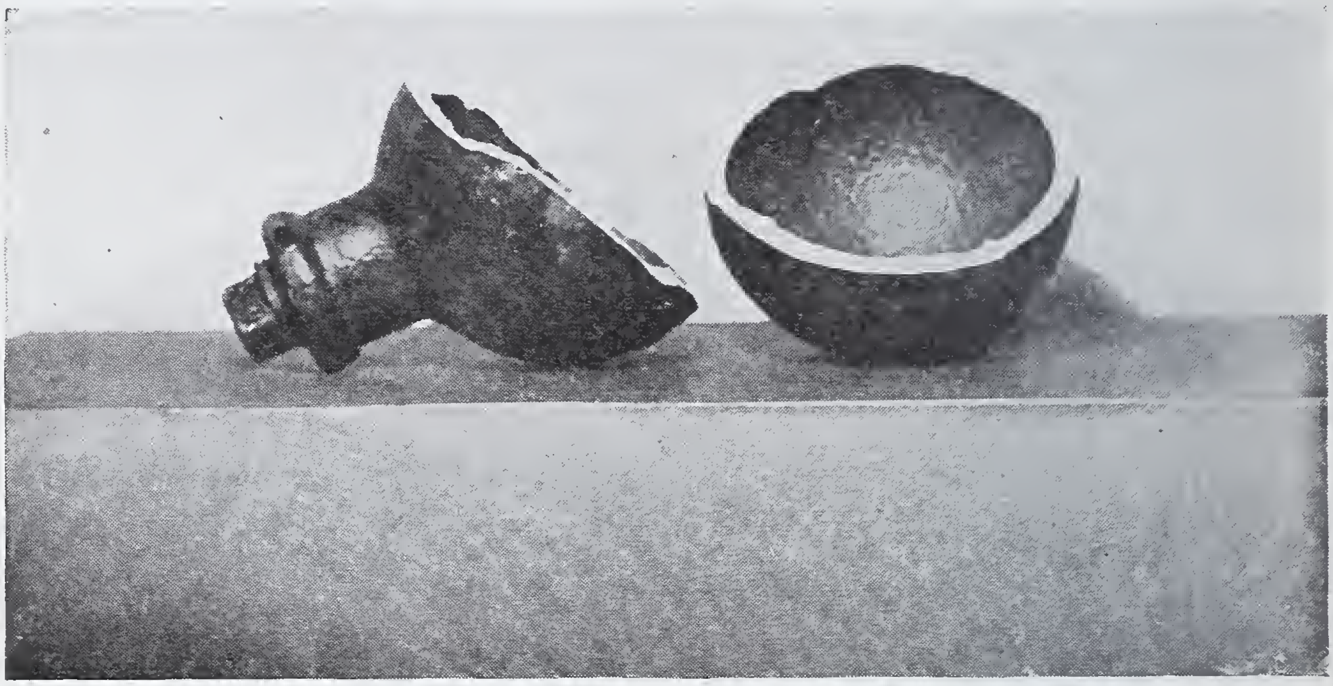


FIG. 2

Iron water bomb broken by freezing water. The metal is three-sixteenths of an inch in thickness.

ICE-DAMAGE The bursting of water pipes in cold weather is caused by the expansion of the water and the formation of ice. Milk bottles may become plugged with ice at the top, and the pressure developed by the rest of the liquid may break the bottle. Freezing cell-sap may burst the intercellular tissue of plants. Freezing serum in meats may disrupt the fibres of flesh, so that after thawing the meat appears pulpy. The meat is not spoiled and is likely to be more tender than the same cut of unfrozen meat.

The water bomb is a laboratory illustration of the force exerted by water while freezing. The bomb is a castiron hollow sphere with a threaded plug for filling. Water that has been cooled to about 6 to 8 degrees C. is placed in the bomb and the plug is screwed in tightly.

Care must be taken to exclude air bubbles, since they would be compressed and the force against the sides of the bomb decreased. The bomb is then placed in a freezing mixture of ice and salt, and allowed to stand quietly for some time. The water will freeze and burst the metal shell. This force exerted is developed gradually so that the sides are pushed out and are most shattered as they would be by an explosive force.

When pure water freezes under a pressure of one atmosphere, a succession of crystal forms gradually connect one another to form a solid piece of ice. At first very long crystals cross the cooled liquid, then shorter forms connect the long ones. Finally, still smaller crystals fill in the liquid spaces and make the mass solid. Under favorable conditions the first crystals that are formed are usually typical ice crystals, while those formed later are changed because of the influence of limited space. Each set displays different properties which are distinguished by a slightly lower melting point.

LIGHT ICE AND DENSE ICE

It is thought that there are two distinct varieties of ice when they are formed under great pressure. The first, or ordinary ice, crystallizes in the hexagonal system and is known as ICE I or light ice. ICE III, or dense ice, is formed by subjecting ice to a pressure exceeding 2000 atmospheres, which reverts to ICE I as soon as the pressure is released. It is possible to preserve ICE III by reducing the temperature to —180 degrees C. It is really in a metastable condition even at this low temperature and will gradually change back to ICE I. If water is frozen when subjected to a pressure between 500 and 2000 atmospheres, a variety is formed which has still different physical properties and is known as ICE IV. ICE II is made by freezing water under pressure of 3000 atmospheres. ICE V has been prepared at 17 degrees C. under a pressure of 3420 atmospheres. This variety passes into ICE VI as the pressure is increased to 6170 atmospheres and the temperature is slowly increased to above zero centigrade. ICE VI has been studied at the comparatively high temperature of 76.35 degrees C. under a pressure of 20,000 atmospheres.

There are various forms of ice which are the result of the condensation of water vapor of the air under different conditions of temperature. Frost is formed by the condensation of water vapor upon surface at a temperature below the freezing point. The loss of heat from these surfaces is usually by radiation. Cloudy condensation

produces ice crystals at temperatures below O degrees C. and is known as "hoar-frost." Sometimes condensed particles that are subcooled are driven by the wind against trees or buildings which results in the building up of feathery ice deposits. This accumulation of ice is known as "rime." Many times during the winter months there are rain storms that follow cold waves. The rain freezes when it comes in contact with surfaces that are cooled below O degrees C. The resulting layer of smooth ice is known as "glaze." Snow is the result of cloud particles freezing in crystalline forms. When rain passes through a very cold layer of air it will sometimes freeze and descend as "sleet." It is only slightly different from "hail," which consists

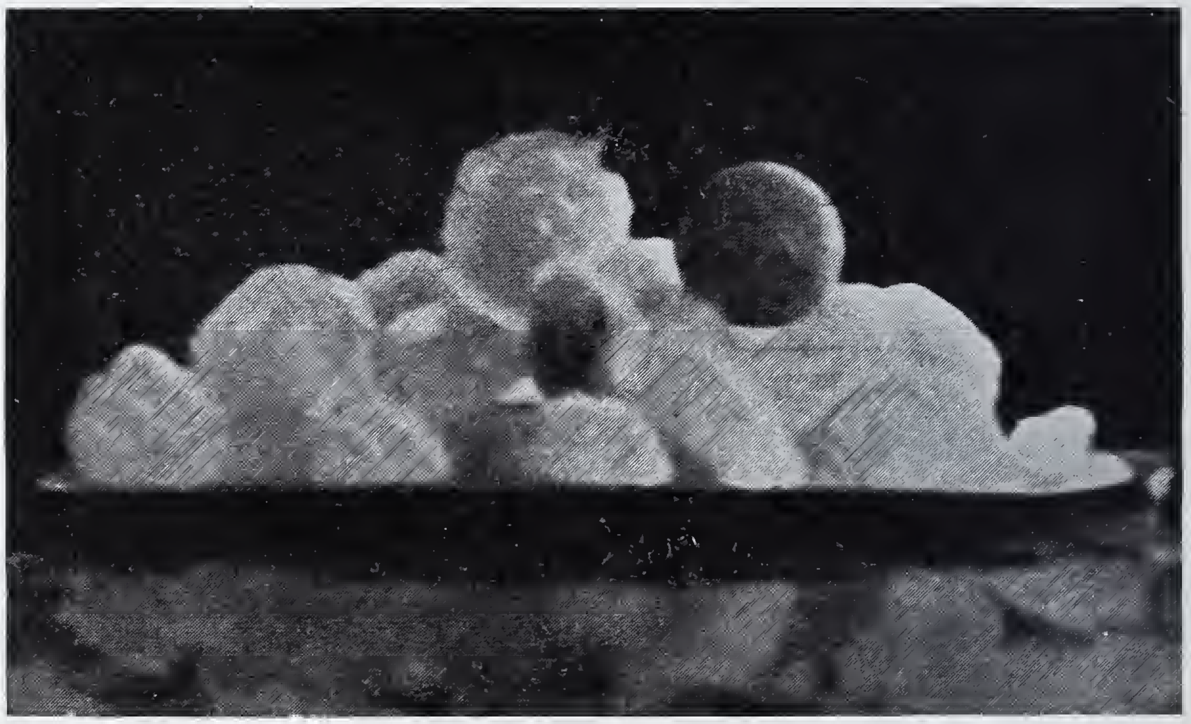


FIG. 3

Hail-stones as large as a tennis ball that fell in South Africa Christmas evening (summertime) 1923.

Photographed by Dr. S. F. Howard.
Photograph from National Geographic, page 78, Vol. 2.

of a core that may be started by a snow crystal or a particle of sleet. This core collects moisture in passing through a warm layer and freezes in passing through a cold area. The ice layers are concentric, making the particle of varying size. Hail particles have been found that were as large as tennis balls.

Hail is only produced during thunderstorms. They are the result of violent convection currents that sometimes prevail during the summer months. The warm current travels upward into the cold air that is below O degrees C. and then passes through another warm humid region. This action is repeated until the hail becomes so heavy that it

can no longer be carried in the air current. It is then thrown from the convection current by centrifugal force.

Nature's greatest source of heat is the sun, while one of its greatest methods of producing cold is by evaporation of liquids. When a substance passes from a liquid condition to a vapor or a gas it requires heat from some source. If the liquid cannot absorb heat from an outside source it will cool and the extent of cooling will depend on the nature of the liquid.

Wind blowing across a water wet body will become cool no matter how warm the air is. The rapid evaporation of the moisture absorbs the heat.

The natives of India use a semi-porous clay in making their water jugs. The water seeps through and keeps the surface moist. When the jugs are placed in a draughty room protected from the sun the water becomes quite cool. Artificial ice has been made in Bengal where no so-called natural ice is ever formed. Shallow pits are partially filled with straw. Trays of water are placed on the straw and exposed to the night air. Evaporation becomes quite rapid as the night air contains very little moisture. Heat absorption is prevented by the straw insulations, and before sunrise a cake of ice will be formed.

The United States Army uses a canvas bag water-container for drinking water. By hanging the bag under a tree in the shade the surface evaporation will cool the contents. In all of these air-cooling devices it is essential to have dry air, either warm or cool, and not air saturated with water vapor.

A striking illustration of water being frozen by its own evaporation is given in the cryophorous. The instrument is glass and is made up of two bulbs about two inches in diameter and separated eighteen inches by a connecting tube. The tube near one bulb is bent 180 degrees. One bulb is nearly filled with water and is heated until steam issues from a small tip on the other bulb. When all the air is expelled the tip is sealed.

The finished instrument after cooling is ready for the experiment. The water is run into one bulb. The other bulb is immersed in an ice-salt mixture. The water vapor is condensed, with the result that more water vapor rushes into the cooled bulb and at the same time the vapor pressure is reduced. This reduction in pressure tends to cause more of the liquid to turn to vapor so that the saturated water vapor condition is maintained. The rate of condensation and evaporation

is so rapid that in about fifteen minutes the water is frozen in the bulb exposed to the air. It is advisable to protect the bulb in the air by means of a layer of cotton to prevent the absorption of outside heat.

ARTIFICIAL ICE Ice was not made artificially until 1755, when Joseph Black, in Edinburgh, succeeded after many attempts. He evaporated water in a Dewar flask by exhausting the flask by means of a water pump. Sixty years later, 1815, Sir John Leslie used a dish of concentrated sulphuric acid under a bell jar in conjunction with the pump. This induced more rapid evaporation. He was able to make one and one-half pounds of ice by this method.

It has been found that it is possible to freeze 80 per cent. of a volume by water by evaporating the other 20 per cent. rapidly in a vacuum, provided the absorption of outside heat is prevented. These various methods were improved until Fleuss designed a machine capable of making three pounds of ice for each pound of sulphuric acid used.

Black's experiments and discovery of latent heat with Cullen's practical application were the forerunners of modern refrigeration. Joseph Priestley prepared ammonia, so extensively used in present-day systems. Robert Boyle and Joseph Louis Gay-Lussac contributed to laws of physics and chemistry on the properties of gases. Michael Faraday showed the relation of pressure to the liquefaction of gases. Thomas Andrews, Count Rumford, Carnot, Mayer, Joule, William Thomson, Claudius, von Helmholtz and many others contributed to the subject of thermodynamics, the establishment of which was so essential to our finely perfected systems of today.

The experiments that have been performed with evaporating water have been repeated, using liquids that have been made by compressing gases in cylinders under pressure. It was found that when the pressure was released the liquid returned to the gas phase with the absorption of heat. It was further found that compressed gases, although not in the liquid phase, on expanding would take up heat. These facts are the basic ideas of the industrial and household refrigerating plant.

The most difficult task in connection with the construction of the mechanical ice manufacturing machine was the design and construction of a proper compressor. Jacob Perkins, an American engineer living in London, designed and patented a machine for compressing ether in 1834. In 1861 the first promising machine with any possible degree of efficiency was used to cool oil for the removal of paraffin.

The Carré ice machine, made prior to 1863, was one of the earliest on the market. The cold is produced by the rapid evaporation of liquefied ammonia gas. It consists essentially of a cylindrical boiler, holding about two gallons, filled three-fourths with a strong aqueous solution of ammonia. The boiler is connected by pipes with a wrought-iron condenser or freezer. The boiler is first placed in a furnace and the freezer in cold water, about 12 degrees C. The boiler is heated to 130 degrees C., which forces the ammonia into the freezer, where it condenses. A can holding about one-tenth by weight of water, as compared to the weight of the ammonia, is inserted into the freezer and capped with a wooden plug. Then the boiler is immersed

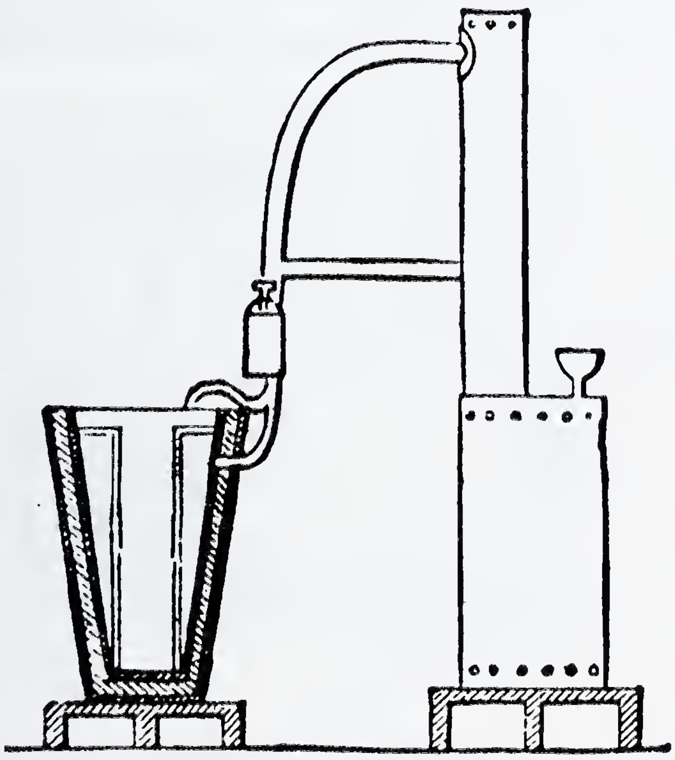


FIG. 4

Diagram of a Carré ice machine similar to an early model now in the Museum of the Philadelphia College of Pharmacy and Science.

From Fownes Chemistry.

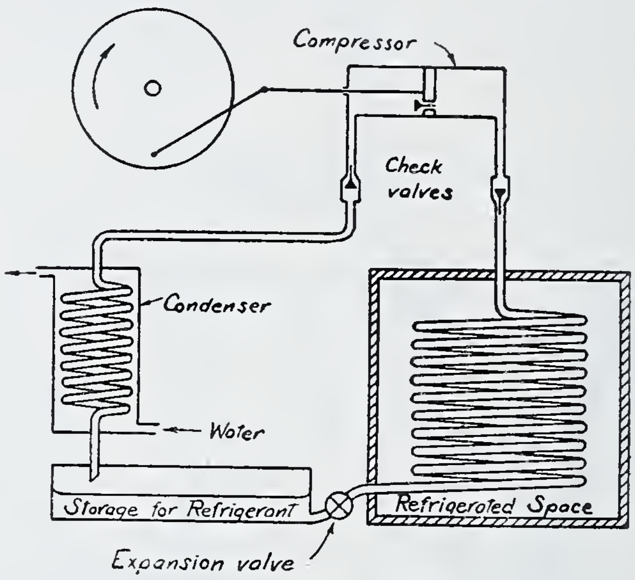
in cold water and the freezer wrapped in flannel. The reduced pressure in the boiler, on being cooled causes the rapid evaporation of the ammonia, which in turn absorbs heat from the water to be frozen. The machine will make about four pounds of ice per hour.

Carl Linde, a Zurich engineer, built a machine in 1874 for compressing sulphur dioxide. This was the most efficient machine up to that time. Experiments followed to determine the best refrigerating fluid to be used for the compressor. Ammonia was used after 1877.

The refrigerating plant is made up of a compressor for changing a gas to a liquid or a densely compressed gas. During this process

there is considerable heat generated. Even the small hand pump becomes quite hot pumping an automobile tire. The resulting liquid or compressed gas is cooled by passing it through iron pipes having water running over them. From the cooler it passes to a storage tank connected to a coil of pipes. The refrigerant is released into the pipes through a very small valve. The expanded gas becomes quite cold and absorbs heat from the pipes which in turn absorb heat from materials surrounding them.

A liquid bath of a low freezing material is used as the medium of heat transfer from the water to be frozen and the iron pipes containing the cold expanded gas. The liquid is a solution of a salt, sodium chloride, or magnesium chloride. A modern plant requires about eight to ten hours to freeze a two-hundred-pound cake of ice.



Compression Machine

FIG. 5

Refrigerating machine of the compression type showing the essential parts.
Courtesy Chemical Foundation, Inc. Chemistry in Industry, Vol. II, page 336.

The expanded gas then returns to the compressor and repeats the cycle of compression, cooling, storage and expansion.

Whether the machinery is driven electrically or steam, the same method is used.

CLEAR ICE A few years ago the ice cakes made in an industrial plant were cloudy at times because of brine contaminating the water to be frozen or because of air becoming frozen in the cake. Today the operator draws the core water out of the can, replaces it with fresh water, and allows it to freeze. The cake of ice is then very clear. Another reason for drawing off the core water is that during the formation of ice the ice crystals will not include for-

eign particles. As the ice layers approach the center of the can the impurities are driven to the center, where they can be drawn off.

The household ice box can now be run on the same system as the large industrial plant, except on a smaller scale. However, there is one type on the market that brings the original method of making ice up to date. This type of refrigerator employs a substance known as silica gel and uses a source of heat such as gas, kerosene or electricity to aid in the production of ice.

Silica gel is the same chemically as sand, but different physically in its structure. It has been known for some time that substances such as sand, when reduced to a very fine powder, had the power to take up large quantities of moisture. If we examine the powder under the microscope we find that there is a space between each particle and that the space had become filled with water. These spaces or pores exert a considerable force known as capillary attraction or adsorption. Powdered sand particles are very irregular and we find that the rough edges decrease the space between particles. The ideal form for such a substance is spherical, so that there is a regular space between each particle. The space would resemble the space that we see between a pile of cannon balls.

Dr. Walter A. Patrick first discovered how to prepare silica in such a form that millions of small spheres would occupy very little space and still exert a tremendous capillary attraction. It has been stated that it is possible to pour four tons of water on ten tons of these small spheres and have it instantly absorbed. In spite of adsorbing this quantity of water, the volume of the silica gel will remain unchanged. The water can be expelled from the gel by heating and it is again ready for use in taking up more water. If we would use some of the same silica gel in an ice box and place a pan of water near it, it will adsorb the water vapor, cause the water to evaporate and cool the box. In time the water will become sufficiently cooled to freeze. After a while the gel reaches the point where it will no longer take up the water vapor. The heat from an electrical heating unit or a gas flame is used to drive off the moisture and allow further adsorption and evaporation. The cycle repeats time and time again without any danger of wearing out. It has no moving parts, nothing to wear out, and is silent.

Other mechanical refrigeration for household use employs sulphur dioxide, ammonia, carbon dioxide or ethylene as the refrigerating gases.

DRY ICE

A one-time scientific curiosity has reached the commercial scale of production. The substance is carbon dioxide snow, known as "dry ice" and "carbice." It is prepared by compressing carbon dioxide and allowing it to expand through a needle valve. The opening of the valve is covered with a wooden box. The expansion is so rapid that the gas solidifies into a white flaky mass. This is compressed into bricks and sold for purposes of refrigeration.

It does not melt in the same way that ice melts, but changes from a solid directly to a gas. The temperature of the solid is from 110 degrees F. to 114 degrees F. below zero and is so cold that it will freeze mercury so hard that a tack can be driven into a board using it

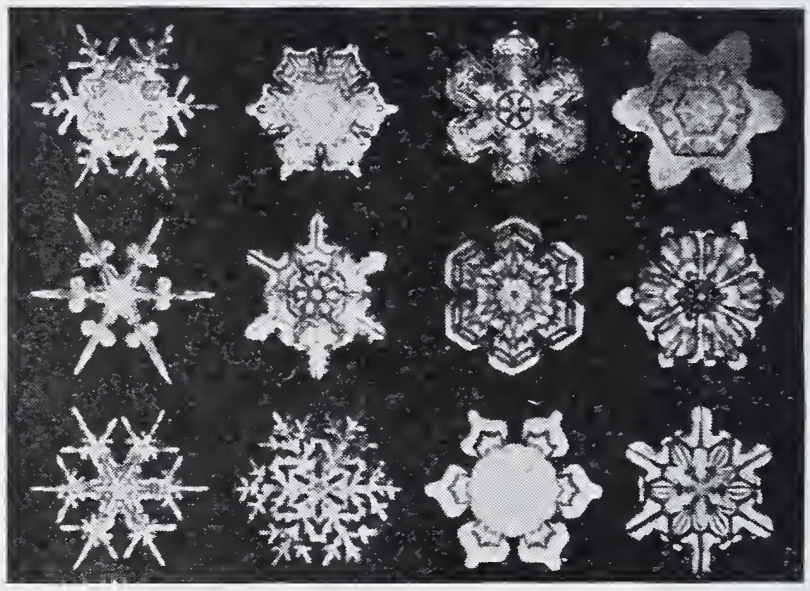


FIG. 6
Photomicrographs of snow crystals.
Courtesy National Geographic.

as a hammer. If we place a piece below the surface of some water it will bubble the carbon dioxide gas to the surface and cool the water.

A temperature below —114 degrees F. is produced when a small quantity of ether is poured on it, producing a pasty mass. The temperature of their mixture falls so rapidly that it will crack glass.

Carbon dioxide snow is used commercially for packing and shipping perishable materials such as ice cream. Heretofore a five-gallon shipment of ice cream packed with ice and salted weighed 150 pounds. The same quantity can now be packed with the "dry ice" or "carbice" in balsam wood containers and weigh but 50 pounds. Because of the extremely low temperature material such as meat and vegetables cannot be packed for shipping in direct contact with it. Care should be

taken in unpacking boxes containing it, to avoid touching it with the hands since it will produce an intense burn.

There are many interesting experiments that might be performed with ice. It is possible to compress snow into a solid mass of ice. The pressure of the hands alone is not sufficient and it is therefore necessary to use a press of some kind. The reason for the formation of the solid ice is that the pressure lowers the freezing point of the snow. It becomes liquid and when the pressure is released it freezes, forming a solid mass of ice.

Another experiment showing the effect of pressure on ice can be carried out using a cake of ice, a piece of string and a heavy weight.

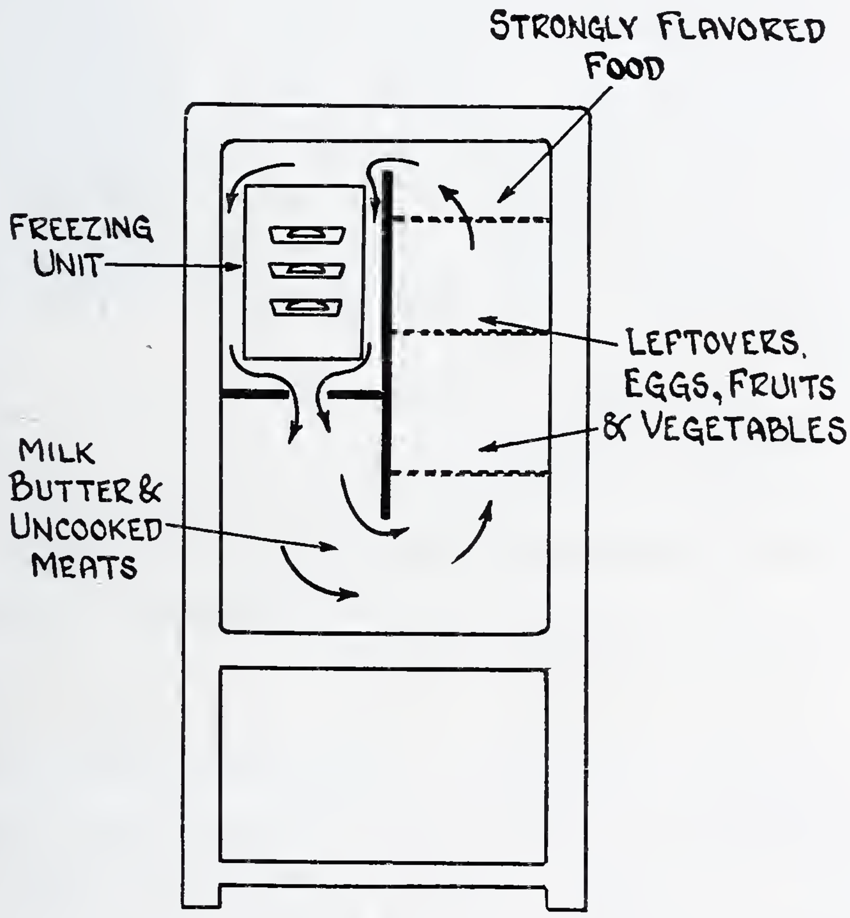


FIG. 7

Chart showing the air circulation and the proper arrangement of food for best results in a typical mechanical refrigerator.

Tie the string around the ice and fasten the weight to the string on the under side. Allow the weight to hang free. Gradually the string will cut into the ice with no visible cut. The pressure of the string causes the ice to melt directly under it, forcing the water produced above the string, where it will again freeze. The action of melting and freezing will continue until the string will pass completely through it without cutting the block in half.

Ice crystals in passing through the air are capable of becoming negatively charged while the air becomes positively charged. During

a snow storm, especially if the air is very cold and dry, it is possible for a lightning discharge to occur because of the accumulation of these changes on the surface of the earth and in the air.

Normally the difference of potential is not great enough in the winter time to produce lightning, since the potential must approach 30,000 volts per centimeter in order to have a lightning discharge.

Ice can evaporate without becoming liquid first. This can be observed on a cold, dry winter day. If a small quantity of water is spread over a large area and allowed to freeze it will soon disappear. Another illustration is that of wet clothing hanging on a line and "freezing dry."

In the days before the electric refrigerator was in the home many people made their ice cream or frozen custards by using a freezing mixture of ice and rock salt. The salt caused the ice to melt rapidly, and in melting absorbed heat from the can containing the cream to be frozen. A mixture of 33 parts of salt with 100 parts of pulverized ice produces a temperature of —21.3 degrees C.

Other mixtures that produce low temperatures are as follows:

25 parts of ammonium chloride with 100 parts snow attains a temperature of.................. —15.4° C.
250 parts of calcium chloride and 100 parts of water attains a temperature of.................. —12.4° C.
Liquid sulphur dioxide and solid carbon dioxide attains a temperature of.................. —82° C.

The story of ice has played a considerable part in the history of the world. Civilization followed the receding glaciers only to be put to flight by their reformation, and still later follow them back again. Today it adds to our health and it is evident that the future will be unable to dispense with it.

THE RARE ELEMENTS

By Freeman P. Stroup, Ph. M.

WE ARE TOLD that the ancients considered that there were four elements—Earth, Air, Fire and Water.

We now know Earth to be a mass of many complex substances and some simple ones; that Air is a mixture primarily of Nitrogen and Oxygen, with traces of Moisture, Carbon Dioxide, Inert gases, etc.; that Fire is a manifestation of certain rapid chemical changes in which volumes of gases are formed and high temperatures produced; and that Water is a relatively simple compound of the elements Hydrogen and Oxygen.

Freeman P. Stroup, Ph. M.

To date nearly 300,000 distinct compounds have been recognized by chemists and classified by them. Doubtless, many more will be discovered as time goes on. More than 250,000 of these are the so-called "Organic" compounds, and the most of them have been identified within the last half century. Most of the substances with which we have to do are mixtures of two or more of these 300,000 odd compounds.

There are known 92 substances which have resisted thus far all attempts to resolve them into anything of simpler composition, and these constitute the "Elements" of modern chemistry. Numbers of the metals in more or less common use are among these, but it must be said that the commercial form of any one of them is rarely pure (free from other substances). The most prominent of these are Iron, Copper, Zinc, Tin, Aluminum, Lead, Mercury, Nickel, Gold, Silver. The Oxygen and Nitrogen of the air we breathe are two gaseous elements found in nature, and Hydrogen (used in a number of important industrial processes) and Chlorine (used largely in bleaching and water purification operations) are two of the most important artificially-produced gases.

Some of the 90 odd elements are found abundantly on the earth, within the earth or in its atmosphere—a few of them in the free state, but most of them in combination with other elements; others occur but sparingly—at least we have not thus far found them in very large amounts. These latter, nearly 60 all told, may properly

be designated "Rare Elements," and it is of some of these that I wish to talk to you this evening, and particularly of some that have come into rather general use within relatively recent years, and are performing duties that are considered as essential to our comfort and happiness.

About 30 years ago the scientific world was startled by the announcement that the atmosphere contains, in addition to Nitrogen and Oxygen, a number of elements (Helium, Argon, Neon, Krypton and Xenon) which are unlike any previously known elements in that they could not be induced to combine with any of these other elements or with one another—were recluses, as it were, or confirmed celibates in the family of elements. The first one discovered was named Argon because of its inert character. Neon was so named because of its newness, Krypton because of its hidden origin, Xenon because it was a foreigner, while Helium (long known as a constituent of the atmosphere of the sun) did not have its name changed just because it was found to belong also to the earth. The amounts found in the atmosphere (in parts per million) are approximately as follows: Helium, 5 parts; Neon, 12 parts; Krypton, $\frac{1}{20}$th part; Xenon, $\frac{1}{40}$th part; Argon, 9350 parts. Excluding Argon from consideration, it is not to be wondered at that these elements escaped detection so long. Their presence in air and their inert characters made them a "seven-day wonder" among scientists, while the average citizen was absolutely unconcerned about them. Probably few persons, if any, imagined that any one of them would ever become of any practical use. Probably all would forever be classed among scientific playthings. But today at least three of them are playing more or less important rôles in the drama of modern chemistry and industry.

Helium has been found occluded in some minerals, but occurs particularly as a constituent of the natural gas found in some of the mid-continent states of this country and in some parts of Canada. From the natural gas it can be separated sufficiently cheaply to permit of its use as the gaseous filler of the gas chambers of balloons and other lighter-than-air craft, to take the place of Hydrogen, Methane and other light gases, all of which are inflammable. It is said to have about 93 per cent. of the lifting power of Hydrogen. Mixtures of the gases Hydrogen and Helium containing up to as high as 20 per cent. of the former are said to be non-inflammable, but whether or not any of these mixtures are ever used in aircraft the speaker

knows not. Someone has estimated that 500 million tons of Helium are going to waste in this country every year, along with the products of combustion of natural gas, yet the country is faced with a shortage for its government-owned aircraft. It has been said that there never was enough "in captivity" to float the Los Angeles and Shenandoah simultaneously, and the country's largest stock was lost when the Shenandoah was wrecked.

Helium's services to humanity are not confined to its lifting powers. It is the filler in certain types of tungsten filament lamps which are used for signalling purposes. The light dims very rapidly. Unusually long sparkgaps are possible in an atmosphere of Helium, and this, together with the pinkish-yellow light produced, makes possible a number of new advertising devices. A mixture of Helium and Oxygen is of great value for deep-sea divers and caisson workers, as it permits of rather rapid "decompression," the process by which such workers are restored to normal air-pressure conditions after having been under abnormal pressure conditions. With the Helium-Oxygen mixture only about $\frac{1}{5}$th the time is needed that is required when air or a Nitrogen-Oxygen mixture is used.

ARGON This element is obtained commercially by the fractionation of liquefied air. Perhaps its most important use is as a filler for so-called "gas-filled" electric light bulbs. Argon-filled bulbs need not be very large, even in high-power lamps such as used as a source of light in projection lanterns. Argon is claimed to be the most efficient available gas for gas-filled lamps, mainly because of its low thermal conductivity. Its density is such as to retard vaporization of the tungsten filaments, this making it useful for currents of high intensity. In 1922 there was an average consumption 75,000 cubic feet of Argon per month in this country in the filling of incandescent light bulbs. Doubtless, the consumption is greater now. The "Tungar" (Tungsten, Argon) rectifier is a battery-charging device using a Tungsten filament in an Argon-filled bulb.

NEON The only other element of this group calling for special mention is Neon. It is also obtained from liquid air. Its chief present use is as a filler for certain types of incandescent electric light bulbs. The light given off by these bulbs is very penetrating and of a pronounced peculiar shade of red which makes it quite desirable in certain forms of advertising devices.

The current consumption is low, and when the light is in operation the whole interior seems to be aglow, no matter how tortuous may be the shape of the glass tube which constitutes the apparatus. Neon-filled lamps are sometimes used in hospitals and other places where a subdued light is desired. In a popular spark-plug tester the peculiar red glow in the tube is due to its being Neon-filled.

RADON (NITON) Belonging to the same group of elements as those heretofore mentioned, but not thus far found as a constituent of air is Radon, also known at Niton and Emanation. It results from the breaking down ("degradation") of radio-active substances, particularly Radium and its compounds. It was not at first thought to be an element hence the name Emanation. It is more soluble in water than the other elements of the group, and is soluble also in alcohol, toluene, amyl alcohol and some other liquids. Aqueous solutions of it are used medicinally both internally and externally, and the gas has been used by inhalation. Its physiological action is similar to that of Radium and it is used in hospitals which cannot afford a supply of Radium or its compounds. Radium and its compounds will be discussed later on in the evening.

RARE METALS Of the present commonly-used metals Aluminum is the lightest, and, doubtless, there are many people who think it is the lightest metal known to man. Not so, however, as there is one (Lithium) that weighs only ⅕th as much for a given bulk. It is so light that it floats not only on water but on gasoline. Certain compounds of it have been used in medicine for many years, particularly for rheumatic and gouty conditions. As an aside it might be stated that not a little fakery has been practiced, at least in the past, on the reputed value of Lithium compounds in these complaints. Many a "Lithia Water" has been sold in tremendous quantities, and people have testified to its beneficial qualities, though the only Lithium about it was the word on the label on the bottle and in the advertising matter accompanying it. Lithium compounds impart to a non-luminous flame into which they may be introduced a brilliant crimson color, hence some of them have found considerable use in the manufacture of pyrotechnic mixtures (so-called "fireworks"). Lately the glass makers have been using Lithium compounds in the manufacture of a special kind of glass.

One of the popular makes of storage-batteries is said to owe much of its efficiency to the presence of Lithium compounds in the

liquid. Within a few years a lot of experimenting has been done with alloys of Lithium. Only last year there were built for a local Berlin (Germany) railway two trains of cars of an alloy of Lithium and Aluminum. This alloy is not only lighter than Aluminum but is said to be considerably stronger.

BERYLLIUM (GLUCINUM) This is another metal that is lighter than Aluminum. For more than a century scientists were baffled in all attempts to isolate it on an industrial scale. It is about a third lighter than Aluminum, but is much harder, scratching glass as readily as does hard steel. It is over four times as elastic as Aluminum and 25 per cent. more elastic than steel. It shows high resistance to the corrosive action of salt water (difference from Aluminum) and other corrosive agents. It has been predicted that airship frames and light-weight machinery may soon be made from this metal and its alloys, and that the metal will soon be as familiar as Aluminum has become within the last two decades. It is not strictly correct to class Beryllium among "rare" elements, as its compounds occur in abundance in nature as minerals, but heretofore were considered as practically valueless. It might better be dubbed a "rarely-used" element. Among the claims made for it are the following:

(a) When added to Silver it will prevent tarnishing.
(b) Ten parts of it alloyed with 90 parts of Copper produces a bronze so hard that a file will not scratch it.
(c) Alloyed with Copper it produces metals of wonderful resonance, particularly adapted to the construction of musical instruments.
(d) Its oxide as a constituent in small amounts of gas light mantles greatly increases their strength.
(e) Its oxide, which melts only at 2450° centigrade, is very useful as a constituent of refractories.

TITANIUM Though one of the ten most abundant elements in the so-called earth's crust or lithosphere, of which it constitutes about 0.73 per cent., Titanium is a rare element in the commercial sense. Ferro-titanium, an alloy of the metal with Iron, is common enough and finds a large use as a "scavenger" for Oxygen and Nitrogen in steel manufacture. It is the only element that burns vigorously in Nitrogen. Its ferrocyanide in fine powder is a fine green pigment, used largely as a substitute for the arsenical

greens once used in wall-paper manufacture. Its precipitated oxide, under the trade name "Titanox," is used as a white pigment, often taking the place of "White Lead." It is claimed to have a third better "covering" power, is not affected by salt water, does not darken as does White Lead, does not bring about saponification of the linseed oil vehicle of the paint of which it is a constituent, and has the important advantage of being non-poisonous. Liquid Titanium Chloride hydrolyzes quickly in moist air, forming a dense white smoke. It has found use in the production of "smoke screens," in "sky-writing," etc.

CHROMIUM This metal, once a chemical curiosity, is considerably in the "spot-light" these days. Compounds of it have been known and used for a long time, but only within a few years has there been any great use for the element itself. Its most outstanding properties are its hardness and resistance to corrosion. In these days one hears a great deal about chromium-plating, and the probabilities are that within a short time it will largely take the place of plating with nickel and other metals so common for years. Tableware (even silver) is being plated with Chromium to give it a hard surface and to do away with the necessity for frequent polishing. Automobile manufacturers are plating radiator frames, bumpers, etc., with it, as well as parts which are subject to much wear. Jewelry, novelties, watch-cases, electrical appliances, surgical instruments, reflectors, plumbing fixtures, barber-shop equipment, restaurant equipment, and building hardware are only a few of the things that are being Chromium-plated to a considerable extent today. The color is somewhat darker than that of Silver, but is really very beautiful and, as one advertiser puts it, "is bright for life." Chromium electro-plate is heat- and acid-resistant, and so we find among its uses the lining of oil-refinery stills and piping, the lining of dairy equipment, the lining of acid-proof containers, the lining of evaporator and condenser tubes, the plating of the rolls of paper-making machinery, and the plating of the rolls used in making plate-glass. Because of the metal's resistance to wear, abrasion and corrosion, Chromium-plated metals find many other applications, among which are machine parts, metal screens, molds of all sorts, engravers' plates, wire-drawing dies, files, gauges, printers' electrotypes. Many of these things may be made of soft and easily fabricated metals, and then Chromium-plated, after which they are as serviceable as if wholly made from the highly refractory metal.

TANTALUM Chemists have been sorely tried in their efforts to find methods for the separation of many elements from the combinations in which they are usually found in the earth, but probably no other element has been more tantalizing to them, nor more tantalizing in its resistance to the action of acids and other chemicals than was the element which somebody appropriately dubbed Tantalum. Though discovered in 1801 it was only recently that an economic method for its production was worked out. Like persons of a retiring disposition, now that a way has been found to coax it out of its natural environment, it has been found to be a really agreeable and useful "member of society" among the elements. It can be worked cold, drawn, hammered, punched, machined, polished, hardened, rolled, etc., but not soldered. It can be brazed to Nickel or Copper. It can be had in pure form as wire, ranging from .001 inch in diameter upward; in sheets ranging from .002 inch in thickness upward, in the form of tubing, gauze, and special shapes. It is used in the fabrication of chemical apparatus, weights, pen nibs, radio-tubes, electric rectifiers and condensers, electric-light bulbs. It has been claimed to be the most resistant metal known—a rather broad statement, perhaps. It resists the action of acids, alkalies, chlorine and other strong chemicals. It has a high fusing-point and, when used as the filament in electric lamps, has a great light-emissive power.

TUNGSTEN If a vote could be taken to determine which of the rare elements is doing the most to make mankind happy the metal Tungsten would poll a heavy vote. "There is probably no element whose chemistry has shown greater development in so short a space of time as did Tungsten in the first twenty years of the present century." It had been known long before and was used as a constituent of alloy steels as long ago as 1855, and its usefulness in steel was no small item; but when it was found possible to produce a ductile Tungsten the metal made a veritable Lindbergh flight into the view of the common people, as then became possible the first really satisfactory incandescent electric light. Tungsten became at once a household word. Besides its use in filament form in incandescent light bulbs, flashlight bulbs, radio-tubes, it is used in pencil form in some forms of arc lights which give off light rich in actinic rays suitable for projection and ultramicroscopic work. Its high melting-point, over 3000° Centigrade, permits it to

carry heavy currents necessary for high degrees of illumination. In many forms of electrical apparatus in the operation of which circuits are alternately made and broken Tungsten contact points have replaced the expensive Platinum and Platinum-Iridium points once used. Its high fusing-point contributes greatly to the usefulness of Tungsten wire in the operation of electrical heating apparatus. Tungsten is a valuable constituent of many alloys to which it imparts particularly great hardness and a high resistance to corrosion. It has been claimed for it that some of its alloys are actually harder than the diamond, a substance which for ages was considered the hardest possible substance. It is a constituent of several alloys that have approximately the same coefficient of expansion as glass, and can be used instead of Platinum for sealing into electric light bulbs to carry current into the interior of the bulb. Some alloys of Tungsten have been suggested as useful in the making of jewelry. One containing 75 per cent. Gold and the other 25 per cent. about equally divided between Tungsten and Nickel is easily rolled, hammered or otherwise fabricated, and takes a finer polish than Platinum. Another with Silver resists tarnish and takes a fine polish. As a constituent of steel Tungsten tends to give great hardness, toughness and elasticity, and to hold these even at red heat. Tungsten steel is largely used in the making of tools to be used in the planing, turning and general shaping of articles made from other metals. With these so-called "high-speed tools" it is possible to turn out machine-shop work at a speed 5 to 6 times faster than when tools of ordinary steel are used. Not a little of the prodigious amount of work done in American machine shops during the World War was made possible by the use of Tungsten high-speed tools. The amplifiers which make possible long-distance telephony and those which make possible the hearing of all parts of a program by every member of a large crowd on public occasions, and which are used to direct crowds in railway stations and other places, owe much of their efficiency to the fine Tungsten wire which constitutes the filament in the tubes used in the apparatus. Tungsten touches human life at many points, and we stop to wonder at times how we ever got along without it.

CERIUM This is a rather rare metal some of whose compounds have been known for a long time and used somewhat in medicine. The metal itself is rather soft and oxidizes readily, so that, when rubbed with a file, it gives off a shower of

sparks—is "pyrophoric," to use a technical term. This pyrophoric property is more pronounced in some Cerium alloys, notably in one containing about 70 per cent. of Cerium and 30 per cent. of Iron. A number of pieces of apparatus, gas-lighters, cigar-lighters, etc., commonly used to ignite gas, alcohol, etc., utilize this property of Cerium and its alloys. An oxide of Cerium is present to the extent of about one per cent. in incandescent gas mantles, the other 99 per cent. being wholly or chiefly Thorium Oxide. Neither one alone gives a good light, both together in the proportions named give highly satisfactory results. People who still have to use gas lamps for illuminating purposes owe much to the bit of Cerium Oxide in each mantle.

THORIUM Mention was made of an oxide of this metal in connection with that of Cerium and the gas mantle. It appears that the brilliancy of the light from mantle lamps is due, at least in part, to rays shot off from the Thorium Oxide present in the mantle—in other words, to radio-activity, a property possessed by this metal and its compounds. Recently a way has been found to produce pure metallic Thorium, and it is now to be had in the form of rods, ribbons, wire, filaments, discs, etc. Perhaps its most important use at the present time is in radio and X-Ray apparatus. "Thoriated" Tungsten filaments in radio-tubes give these tubes many advantages over non-thoriated filament tubes. Some commercial luminous paints owe their luminous properties to their containing small amounts of Thorium compounds.

RADIUM The existence of this element has been known for only a few years, but so wonderful have been some of the things that have been accomplished through the use of its compounds that nearly everybody can tell us something about Radium. It is interesting to note that to produce 100 milligrams (about one and one-half grains) of Radium Bromide requires (so it has been said, at least) 12 tons of ore, 3 tons of Hydrochloric Acid, 5 tons of Sodium Carbonate, 1 ton of Sulphuric Acid, 1 month's labor (number of men not stated), and 500 successive crystallizations. No wonder it is expensive. The world's supply of extracted Radium is estimated to be about 5 ounces, and the average increase per year is about 1 ounce. The present uses of Radium and its compounds all are dependent upon the tendency of this element to give off several

kinds of so-called "rays," each having important properties. Some of them have pronounced physiological action and a great deal of research work has been done in efforts to find out to what extent these may be beneficial and to what extent they may be harmful. In this connection it should be said that a great deal of fakery has been practiced on the unsuspecting public by unscrupluous charlatans who are ever ready to capitalize to their own profit every new lead opened by scientific discovery. Many preparations which are claimed to contain Radium or to be Radio-active contain no more Radium than does the dust of the street, and are no more radio-active than is a glass of hydrant water. Outside of the use of Radium compounds in medicine there is a rather wide use of them in luminous paints. Yes, there is a trace of a Radium compound in the whitish covering of the hands of self-luminous watches, and on the figures on the face of the watch. Luminous watch dials are said to have from 10 to 20 cents worth of Radium on each, usually intimately mixed with a specially prepared Zinc Zulphide which constitutes the bulk of the pigment. Night-flying air-planes have as high as 9 instruments with luminous dials containing Radium.

MOLYBDENUM This element, a metal, has been put to a number of important uses in recent years. It is used to support the Tungsten filaments in electric-light bulbs; an alloy of 20 per cent. Molybdenum and 80 per cent. Tungsten makes a very satisfactory electric light filament. It often replaces Platinum as the metal for making the "grids" of audion wireless "tubes," and for the "plates" of high-power "tubes." Alloys of it with Chromium and Cobalt are among the so-called "stellite" alloys, which resist tarnish, are not easily scratched and take keen edges, these three properties fitting them for a great variety of purposes, the making of stainless cutlery particularly. Molybdenum steel is characterized by pronounced hardness, toughness, elasticity and tensile strength. Its hardness seems to increase with age, hence it is recommended for the construction of bank vaults, safes, etc.

In our discussion this evening we have had time to consider only a few of the more outstanding of the rare elements that have come into more or less extended use in recent years. Time does not permit the consideration of the Platinum Group of metals, Gold and Silver (which are "rare" for many of us), and a lot of others which, though rare, have been of use to mankind long enough to be

considered at length in encyclopedias and books on popular science. The chemical curiosity of today becomes the useful servant of man tomorrow; perhaps in a few years we may be able to present to you an array of new facts concerning some of our today almost unheard of elements which will be of even more interest to you than those given you this evening.

EUROPEAN FLOWERS IN COMMERCE AND CULTURE

By Professor E. Fullerton Cook

THE MEMORIES of a year in Europe have many ramifications. History, at each turn, forces itself upon one's attention. Mediæval castles with their embattled towers and moats and swinging bridges, become a daily experience but never lose the power to thrill. History lives almost unchanged; one finds one's self in a town of the twelfth century, with the walls still intact, as in Murten, Switzerland, and then within another five miles discovers the ruins of the old Roman capital of Helvetia, Aventicum, two thousand years ago a city of 250,000 people and where still may be seen ruins of the temple of Apollo, the Roman theatre, the Coliseum, rich with mosaics and many forms of architecture and statues of Roman origin. This is Europe, from one angle.

E. Fullerton Cook, Ph. M.

Perhaps one is interested in art and then the great galleries of London, Antwerp, Amsterdam, Brussels, Venice, Florence and innumerable other centres of art treasure satisfy the artistic soul.

If people interest the traveler, they are as varied and as delightful in their native valleys and villages as can be imagined, for there they live and die as for five hundred years before them their progenitors have lived and died perhaps in the same house, carrying on the same customs and having the same problems, for they have been set in a mold of tradition and have not yet felt the stir of our age.

But for us flowers are the theme. They reflect the desire to create, the love of the beautiful, and the pride of possession, all innate qualities of the human heart. May in Normandy—apple blossom time! Can the imagination picture a scene more beautiful? Fields are intensely green and splendid highways run across France, flanked for miles and miles on both sides by tall trees. Men and women are working in the fields, the oxen are slowly drawing the plough and there in the fields of vivid green, dotted with innumerable scarlet poppies, how spontaneously comes to mind the war poem, "In Flan-

ders' field the poppies grow." It would seem almost as though the blood-soaked earth returned the precious gift of life. From LaHavre to Ancient Rouen and to Paris, and then the first glimpse down the Champs Elysees of the Arc de Triomph. All decorative gardens seem to be imitations in comparison with those in Paris or in its environs. Here are artistic creations and floral decorations on the Place de la Concorde, and in the gardens at Versailles, which stand supreme. Frederick the Great built his palace at Potsdam, the Sans Souci, to rival Versailles, but the grandeur created by Louis XIV remains unexcelled.

Beneath the Arc de Triomph burns the perpetual fire by the tomb of the unknown soldier. Here with uncovered heads stand men and women from all corners of the earth, in appreciation of the spiritual significance of that symbolism. Flowers typify the desire to worship at the feet of the heroes of the war which stirs every heart and there may be found the costly wreath, laid at the warrior's feet by king or nation, and by it—equally honoring the dead—may be seen a tiny bunch of field flowers left by some one who has sensed with equal meaning, this expression of devotion.

At the tomb of the unknown soldier in Brussels is found the same instinctive expression of homage and in Westminster Abbey, where the following inscription stirs the heart, again is found the tribute of flowers from rich and poor, the humble and the great.

> "Beneath this stone rests the body of a British soldier, unknown by name or rank, brought from France to lie among the most illustrious of the land, and buried here on Armistice Day, 11th of November, 1920, in the presence of His Majesty, King George V, his ministers of state, the chiefs of his forces, and a vast concourse of the nation.
>
> "Thus are commemorated the many multitudes who during the Great War of 1914-1918 gave the most that man can give—life itself—for God, for king and country, for loved ones and empire and for the sacred cause of justice, the freedom of the world. They buried him among the kings because he had done good toward God and toward his house."

From Paris, through Dijou, on to Berne in Switzerland we went through a continuous panorama of the spring, of green fields, blossoming orchards, and the new green of the forests. Nine months in Berne and the Bernice Oberland, continuously impresses the visitor with the truth that Switzerland is a flower garden. Crossing

from France, from Italy, or from Germany, one seems to step from struggle and hardship and the stern realities of life, with little or no esthetic expression shown through the country side, into a land of flowers and color. The difference is instantaneous and is felt whether the picture be a farm house, a small village, an outlying hut, or the modern city; flowers are everywhere.

The rich, prosperous chalets of the country, built so artistically, always have flower-boxes at the windows and vines and flowers the entire length of the galleries which are so characteristically a feature of the architecture, and then there is the invariable flower garden,

A Flower Garlanded Swiss Chalet.

probably very formal in its design. Where else can one see the rose bush or the fuschia, trimmed to simulate a small tree three or four feet in height, and with a luxurious, leafy spread at the top bearing masses of magnificent blossoms.

The Swiss house and barn, of course, are under one roof and about them three essential elements are sure to be found: First, the store of firewood, mostly piled into unusual shapes often forming a beehive twelve to fifteen feet high and of equal diameter. Second, another evidence of health and prosperity, said to be the gauge of importance in the community, is the manure pile. This is usually square with the sides made of twisted straw, woven like a basket

and usually represents tons of fertilizer. Flowers may be abundant but it is not always the odor of flowers one notices. However, this is accepted as a part of the wealth of the land and as a necessity.

Then the third feature of every home is the fountain of running water. An Alpine source is tapped and the cold stream of crystal clearness usually flows into a stone bowl with the refreshing sound of running water. Here again are the flowers, for one commonly sees potted plants in bloom carefully arranged about the fountain.

If one lives in Berne or any other Swiss city almost every home has a garden and flowers, but, if not, the Tuesday or the Saturday market, to which come the farmers for miles around, affords a riot of color. Many of the farmers can still be seen bringing their garden truck on carts pulled by huge St. Bernards or other powerful dogs, or perhaps an old woman gardener hitching herself to the shaft with the dog.

Here before the stately Parliament buildings, one may buy huge bunches of flowers or potted plants for a few cents and no matter how humble all who market seem to carry away a bunch of flowers. In every home these seem to be as essential as food.

On two sides of Berne, through which the river Aar winds its way, arise hills, one of which may be classed as a small mountain. From the crown of the smaller eminence may be obtained a magnificent view of the snow-capped Alpine range, forty miles distant, that is, when the clouds or mist permit. Here the city had laid out a rose garden of considerable area. As elsewhere in Switzerland these roses have been carefully trimmed to resemble small trees; a long sturdy stalk, and then a mass of foliage, on which bloom the most magnificent flowers. Here has been established a formal garden and an attractive tea-house and one may spend the afternoon and revel in the view on the one side of the Oberland, and on the other of the quaintly shaped, red-tiled roofs of the city, with the tower of the Munster rising majestically in the distance.

It is typical of the Swiss that a factory should be made beautiful. The building itself would resemble our finest apartment house, with the grounds laid out with flowers and shrubbery. With the high hills north and south of the city, the valley runs east to Thun and to the Bernese Oberland. To the west, up to the edge of the town, rises a splendid forest. One may motor for hours through its vaulted canopies, at times with the foliage so dense that the sun cannot penetrate. Here scientific forestry is practiced as elsewhere in Switzer-

land. The woods are owned by the Canton, or State. These nationally-owned forests are primarily for the benefit of citizens and any resident may have all that he needs for fire wood or for building without cost except that for cutting and hauling. Yet not one tree may be cut without the consent of the professional forester and for each mature tree felled, three new ones must be planted. Many times they are planted so regularly and their trunks are so straight and tall that one may catch through the forest, vistas of columnal aisles, roofed by arches of green. The floor of the forest is as clean as though it were swept, for the people gather every twig for firewood.

Formal Gardens. Place du Carrousel. The Louvre, Paris.

A group of University students go with me by third-class train from Berne to Wattenwil. Most of them wear spiked shoes and carry sticks and "rooksacks" in which are carried concentrated soup, bread, cheese, sweet chocolate and an alcohol stove. Extra warm socks and a blanket and sweater are a part of the equipment. The objective of our climb is the crest of the Gantrisch, which is but one of the fore Alps and, although not snow-capped in the summer, is still high enough to pass the timber line and is just the setting for the finest Alpine flowers.

The higher we climbed toward the snow-line the more brilliant is the coloring and the larger are the wild flowers. The buttercup

of the green fields at home, with its waxen petals, is justly loved by the children, but the buttercups high up on the Alps (Trollius europæus), called by the Swiss, Ankeballeri, doubled up as they all seem to be, form a ball of gold, often an inch in diameter. It is also a privilege to see for the first time and learn to know the delectable perfume of that tiny garnet-colored flower known as Branderli (Nigritella nigra). It is as distinctive and as delightful as arbutus. The flower is only found in the high altitudes and is usually associated with that wonderful bloom, growing in the snow, the Eidelweiss.

Here on the high Alps may be found a large variety of lovely

Hydraulic Press Room—Pomade Manufacture—Hot Process.

flowers. Perhaps the most outstanding example is the Alpine rose—Rhododendron ferrugineum. Its glorious patches of red are to be seen for a long distance up the side of an almost impassable cliff. No wonder the Alpine climber is willing to risk his life and glad to have the thrill of a scramble up or down an almost perpendicular cliff to obtain the reward of the "mountain rose."

Among the outstanding flowers on the mountain-top are the blue Enzion, of medicinal value (Gentiana asclepiadea); the Colchicum, the flowers blooming in the midst of melting snow high above the valleys. Then one finds the Primula, Saxifrage, Anemone, Arte-

misia, Asters, the official Gentiana lutea, Soldanella alpina, Myosotis alpestris, Pedicularis rostrata, Ranunculus glacialias, Anthemis alpistris, Satureja alpina, Tussilago, Atragene alpina, and hundreds of others.

The fields of narcissus are one of the famed beauties of Switzerland and in the country around Montreux. Hundreds of tourists come here in the spring of each year to see this wondrous sight.

When you next visit Geneva make the approach if possible by motor over the hills above Lake Geneva and wind your way by circuitous turns through the ancient vineyards above Vevey. It seemed

Enfleurage—Pomade Manufacture—Cold Process.

to require an hour just to come down to the shore of the lake and every inch of these gigantic hills is covered by terraced vineyards. To look back is but to see wall upon wall rising to the very crest of the hill, and then, on these walls, clinging, without apparent support, are spherical masses of purple flowers, a color most gorgeous. In this strange setting with the background of great walls, they resembled huge amethysts.

Geneva, the international city, has its own charm and the drive along the lake through Lausanne, Vevey and by the Castle of Chillon brings one to the cold, stony and, this day, wind-swept and snow-

driven valley of the Rhone. We are back in the clutches of winter and when Brigg is reached, at the foot of the Simplon Pass, it is hard to believe that flowers can be blooming anywhere. The pass is still snow-bound but the longest tunnel in the world carries us into Italy, and to Domadosella, where we saw first the swaggering soldiers of Mussolini and a Red derby hat. Nowhere in the world can one find such picturesque military costumes.

Again we are on the road and in a few hours the glories of an Italian lake, Lake Maggiore bursts suddenly upon us and with it all the evidences of spring—not that of cold Switzerland but of

Perfume Extraction with Volatile Solvents.

warm and sunny Italy. Flowers of brilliant color, gardens and tropical palms, beautiful villas and tinted palaces, pink or lavender, with the indescribable, azure-tints of the lake. Then come the days of travel to Milano, and from there, across Italy, to Verona, Venice, Bologna and Florence, each with their peculiar charm. And now, that wonderland of color and flowers, the Riviera. The height of mountains bordering the entire Riviera is a surprise. Every charming town and harbor seems to be isolated by the surrounding hills and it is no unworthy adventure to wind one's way up these mountain roads to the crest and then to drop again to another beauty spot where

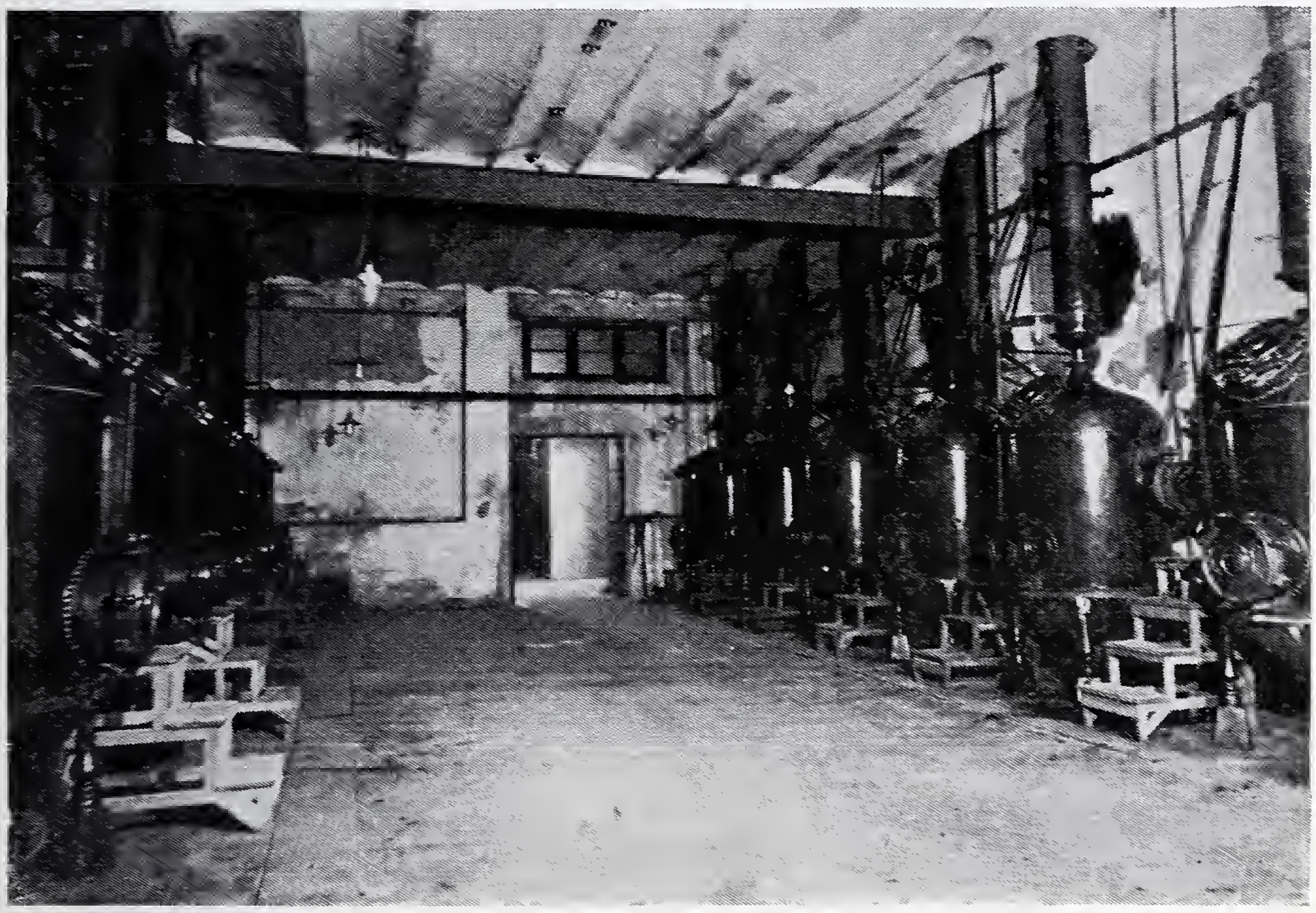
man and nature have vied in providing charm, and delight, and also entertainment for the thousands who come from every corner of the globe. Repeatedly on this drive we were rewarded by a view of indescribable loveliness. The blue of the Mediterranean is not exaggerated in picture or story. The rocky coastline, the deeply cut harbors and jutting land add picturesqueness to the picture. From Siestri Levante following the coast, the Cote D'Azur, for one hundred miles through Menton, San Remo, Monte Carlo, to Nice and on to Cannes, both the natural and artificially arranged floral displays are probably unexcelled.

The formal gardens of Menton, Monte Carlo, Nice, San Remo, bordering the Mediterraneon coast, thrill the visitor by their gorgeous colors and jewel-like setting in the surrounding hills, but there is a sense of the artificial and as you turn north into the mountains over that unrivalled boulevard, the Grande Corniche, with the blue of the Mediterranean meeting the horizon and the ribbon-like highway to the very peak of the mountain, then dropping precipitously into the valley, over high bridges and mountain streams, here the true beauty of this natural flower-land is seen.

More and more the tourists are being lured over these lovely roads to Grasse, the historic perfume center of the world. A quaint mediæval city built on the hills, with arcaded streets often too steep and narrow for modern travel methods—in fact many streets are but a series of steps. Here for a century the flowers have been brought in from the surrounding hills and their elusive perfume seized and concentrated for the joy of those not fortunate enough to live on the Riviera. Here nature has provided all of the conditions; the warm, moist breezes from the Mediterranean, the high hills to shelter the flowers from the north winds, the olive groves upon whose carpeted floor the violets naturally grow. In this land where flowers have been cultivated for centuries by lovers of flowers there is a continuous but seasonable flow of perfumed harvests into the factories of Grasse.

Violets, jasmine, mignonette, tuba rose, orange blossom, carnation, and lilac each in turn find their way to the perfumer, who skillfully and artistically extracts their essence of delight. When one realizes that it is estimated that 1700 pounds of violets are needed to make one pound of "violet absolute" it is not surprising that the market price today of violet perfume stock is fifteen hundred dollars a pound or that the jasmine blossom yields perfume in such small

amounts that a pound of the essence costs seven hundred dollars, and yet it is this concentrated perfume which alone makes possible modern perfumery and the world comes to Grasse, for its supply. True, the synthetic chemist elsewhere has reproduced marvelous odors, finding their place in the production of perfumes, but the finer natural odors yet defy the skill of the chemist. Synthetic jessamine may be made to resemble the true flower odor, yet there are elusive esters or alcohols in the natural flowers which have not yet been reproduced or even identified.



Distillation of Orris Root.

In travelling through the hills surrounding Grasse everywhere small farms abound where are grown these perfume flowers and the imagination must be given full play to visualize the reality.

But I have said little about medicinal flowers and time will not permit an extensive consideration. Yet these lovely colors and delightful perfumes have a part directly or indirectly in the production of some of the most important of our modern therapeutic agents and many others find a place in domestic uses of no less importance.

First the flower, then the fruit and seed and through this channel come the potent medicinals, morphine, codeine, strychnine, colchicine and strophanthin.

When the linden tree blooms, young and old gather the flowers and carefully dry them for they seem everywhere to be prized for the preparation of a domestic tea. Even in Berne authority is given to the city officials to collect the linden flowers from the trees in the parks and on the street.

Evidently the housewives on the farms in Europe cultivate many medicinal flowers and dry them with the utmost care for the commercial product. The collection of medicinal flowers presented to the writer by Dr. Siegfried of Zofingen, Switzerland, include the following and this but represents a few of the most striking forms selected by myself from his huge stock:

Flos althææ
Flos anthos
Flos anthyllidis
Flos bellidis
Flos buglossi
Flos cacti grandifloris
Flos calcatrippæ
Flos calendulæ
Flos carthami Pers.
Flos cyani la.
Flos farfaræ
Flos granati
Flos genistæ
Flos hyperici concisus
Flos lavandulæ
Flos malvæ arboreæ
Flos malvæ
Flos meliloti concisus
Flos pæoniæ
Flos pedis cati
Flos primulæ veris
Flos rhoeados
Flos rhododendri
Flos rosæ pallidæ
Flos scabiosæ
Flos stœchados citrinæ
Flos tiliæ
Flos violæ electus
Flos violæ tricoloris

One of the most striking color contrasts of the spring in Europe are the fields of bright yellow, the Sesame in bloom, as a mantle of gold spread upon the verdant hills, and from its seed is pressed an oil of large food value.

Many of the medicinal drugs of the modern vegetable materia medica come from Europe and, while their commercial form is not always the flower, the flower plays an important part in their identification and study and nowhere else has such pains been taken to reproduce their form and color for the education or pleasure of those who cannot see them in their natural surroundings, Digitalis, stramonium, veratrum, aconite, valerian, belladonna, gentian, arnica, etc., are among these drugs.

Another flower which recently has made for itself an essential place in our civilization is the small composite flower, pyrethrum, from which the so-called "Persian Insect Powder" is made and more recently the liquid "fly and mosquito killers," which are adding so greatly to the comfort of our summer days and nights.

And so this excursion into flower lands has led our thoughts among varied scenes and interests always with the inspiration of the beautiful. That there may be no discordant note I leave with you the thought of the return of another spring in Normandy, and the anticipation of our own wonderful land of blooming flowers in the merry month of May.

FLAME

By George Wesley Perkins, B. Sc., M. Sc.

Instructor in Chemistry

THE WHYS AND WHEREFORES of a "flame" have ever been of interest to men of inquiring minds. The ancient philosophers considered the flame, or fire, an *"essential"*; to us, it is more than ever essential. The very beginnings of modern chemistry take place in the efforts of scientists to define and explain the meaning of flame. Fire is an aggregation of flames and to the scientist, it is a form of energy change called combustion. We can only briefly tell you in this lecture some interesting things about fire, flame and combustion.

George Wesley Perkins, B. Sc., M. Sc.

The origin of fire was attributed by the ancient Greeks to the two gods, Prometheus and Epimetheus, who, it is alleged brought down fire from heaven. The Persians ascribed the discovery of fire to a dragon fighter, *Hushenk,* who threw a rock at a snake and missed it, but struck another rock giving a shower of sparks. An ancient legend of the North American Indian narrates that the *Great Buffalo,* racing through the plains, set the prairies afire by striking sparks from its hoofs. A similar thought in Hindu mythology conceives the idea that thunder is the clatter of solar horses on the *Akmon* or hard pavement of the sky. The various ancient gods of the Tartars, Lapps, Gauls, Scandinavians and Finns have been depicted as having in one hand a flint and in the other a piece of iron, striking off great sparks or thunderbolts.

We know that man had knowledge of some uses of fire in very ancient times. The prehistory of man is divided by anthropologists into three eras: first, *Eolithic Man,* a period ranging from 100,000 to possibly millions of years ago; second, *Paleolithic Man* (rough stone or old stone age), a period ranging from 100,000 to 10,000 years ago; third, *Neolithic Man* (polished or new stone age), which brings us to the *Bronze Age* in comparatively recent times. In some parts of Europe, particularly southern France, certain caves have

been found containing human skulls and bones and other debris known as *artificats* which have been estimated to date back 50,000 years to the Aurignacian Division of the Middle Paleolithic Period. The floor of the front part of these caves contains charcoal and ashes indicating that those ancient creatures had a fire burning before the entrance to their domicile. After a long period of time man became more adept in the use of fire and in the Neolithic Age we find him beginning to make crude pottery.

THE FIRST FIRE

Where man first obtained his fire we can only speculate. Perhaps he obtained it from the hot lava flowing from a volcano, or from a burning tree struck by lightning. It is barely possible that he may have obtained it by striking sparks from a piece of flint and a piece of pyrite. The production of fire by friction was known to the Australian and Tasmanian aborigines. The Indians of North and South America and the ancient Chinese and Mexicans made fire by friction in many different ways. The use of the burning glass was also known to the old Greeks and Chinese.

Fire loomed so important to the ancients that it was considered a fundamental or essential part of matter. A Greek by name of *Heraclitus* (540-475 B. C.) believed fire to be the primordial substance from which all other matter was generated. Most of the ancient thinkers concurred in believing matter to be composed of four *elements;* Earth, Fire, Air and Water. Aristotle (384-322 B. C.) defined the four elements as follows:

Earth —Cold and dryness
Fire —Heat and dryness
Air —Heat and moisture
Water —Cold and moisture

Plato gives us one of the first definitions for fire, stating that it is "burning air." We shall show you by an experiment later that this is possible. The Aristotelian idea of the elements prevailed for a long time, and as late at 1712 a Swedish chemist, Hjärne, stated that fire was the foremost element, in contradistinction to the Dutch chemist Van Helmont (1577-1644), who said that flame was only illuminated smoke.

THE PHLOGISTON THEORY

There is a period in the history of chemistry closely linked with the definition of flame, during which the *Phlogiston* theory was in vogue. This theory was the conclusion of observations on substances that would burn and on substances that had been calcined or roasted. The physical natures of the substances during burning or calcination were completely changed, giving rise to the thought that some common component was lost in the act of burning. A German, Becher and his pupil Stahl, were foremost in the promulgation of the theory.—"Stahl named the igneous principle *phlogiston,* meaning combustible. He regarded phlogiston as the principle of inflammability—the fire matter which existed in combination with other bodies. Phlogiston, in the mind of Stahl, was a hypothetical element—a pure fire, fixed in all combustible bodies, and was to be distinguished from fire in action or in a state of liberty. He declared that all combustible bodies were composed of phlogiston and a non-combustible substance. . . . This theory, of which so much has been written and so much has been said, briefly stated is this: Combustion depends upon some principle which is present in every substance. This principle, identical in all combustible substances, escapes during combustion. Phlogiston is the principle igneous or the principle combustible. In combustion, the phlogiston passes out as a flame, while the non-combustible portion of the body remains; hence, the term 'dephlogisticated' corresponds to the present term 'oxidized' and 'phlogisticated' corresponds to the term 'reduced' . . . In this connection it is interesting to learn the ideas entertained by chemists, other than Becher and Stahl, concerning this igneous principle or phlogiston. Some identified it with light, with flame, with coloring matters (particularly Prussian blue), with hydrogen, with the principle of levity or of negative weight and the like."

Some of those older chemists had a naive way of surmounting difficulties. One of these was the fact that most types of combustion needed air. Hence they stated that phlogiston did not go away during combustion but united with the air or some part of it, and when no air was present the fire went out because there was nothing for the phlogiston to combine with. One of the last chemists to defend this doctrine was an Englishman, Joseph Priestley (1733-1804), whose greatest achievement perhaps, was the discovery of the gas oxygen. In keeping with his belief, he called the gas *"dephlogisticated air"* because he thought that it was the component of the at-

mosphere with which phlogiston united when it emerged from a burning substance. Nitrogen was a gas in which ordinary substances would not burn, hence it was believed that nitrogen was saturated with phlogiston or could not take up any more phlogiston and it was then called *"phlogisticated air."* Because of persecution due to his theological views Priestley moved from England to Philadelphia, and later to Northumberland, Pa., where he built a home now used as a Priestley museum. While in Philadelphia and Northumberland just before his death he wrote several pamphlets vigorously upholding his views and beliefs in the doctrine of phlogiston and refuting the composition of water. Priestley was a brilliant experimenter but unfortunately did not draw the right conclusions concerning his experiments. He was so sure that something was given off in burning that he could not see that the burning substance was uniting with one of the gases in the atmosphere. His primary thoughts however, were more concerned with theological matters, as he tells us in one of his last writings. "But my philosophical friends must excuse me if, without neglecting natural science, I give a decided preference to theological studies, and if here, as in Europe, I give the greatest part of my time to *them*. They are unquestionably of unspeakably more importance to men, as being designed for immortality . . . "

"MAKING FIRE" When the modern housewife strikes a match to make a fire today, she no doubt little knows of the inconveniences our forefathers had to endure to obtain a fire. One of the earliest methods used to obtain a flame was by heat from friction. Several variations of this method were employed. "Drilling" fire was twirling a dry stick between the hands with one end of the stick in a hollow in another stick. The heat generated between the two surfaces would set fire to dry leaves or twigs. The stick was often twirled by using a bow, by wrapping the bowstring once around the stick and sawing back and forth. Another method that is very old and still used in comparatively modern times is the use of a hard stone like flint, and a piece of pyrite. Pyrite is a mineral containing iron and sulfur. When the two are struck sharply together a bright spark is emitted. The spark is caused to strike some dry material that will readily ignite. It is very reasonably supposed that the men of the New Stone Age and the Bronze Age were familiar with making fire in this manner. In later years a piece of iron or steel was substituted for the pyrite. The force of the blow of the

flint on the pyrite or iron causes a very small flake to be struck off and the heat from the friction of the blow causes the tiny chip to glow. The glowing spark is further caused to burn by the oxygen of the air making it hot enough to readily ignite suitable dry material. For a long time the old "muzzle-loaders" and other firearms were ignited by using a piece of flint, hence we had the "flintlocks." Everyone is familiar with very modern forms of these "fire-strikers." When iron is alloyed with a small amount of the rare metal cerium, it will emit a shower of bright sparks if it is properly manipulated. The cigarette lighters used today operate in this manner. A milled wheel turns against a piece of this alloy giving sparks which ignite the inflammable material in the container.

THE FIRST MATCH

The first *chemical fire-lighter* was invented in 1770 by Fürstenburg and improved in 1824 by Döbereiner. Hydrogen gas, which is very inflammable, was generated in a suitable vessel and allowed to escape over a piece of porous platinum. A physical-chemical action takes place, the platinum absorbs or condenses some of the gas with the generation of sufficient heat to finally ignite the gas. Several other types of chemical lighters were invented in the early part of the nineteenth century. A Frenchman, Chancel, developed the ancestor of the common match in 1805. When potassium chlorate is mixed with sulfuric acid in the presence of substances that readily burn, the substances will ignite. Chancel coated the ends of small wooden sticks with a thin layer of sulfur on the tip of which he placed a small mass of potassium chlorate, sugar and gum to bind it. The matches were dipped in the acid which started the reaction. An improvement on this was invented in 1832 by Trevany. The ignitor or tip of the match was a mixture of potassium chlorate and antimony sulfide. A sulfur dipped stick was still used and when the tip of this match was drawn rapidly over a piece of sandpaper the match became ignited. The first phosphorus matches were made in 1816. The first phosphorus matches were made with yellow phosphorus, the tips often exploded, and because of their easy combustibility they were dangerous. Later red phosphorus was discovered and because it was not so dangerous attempts were made to substitute it for the yellow variety. In 1848, Böttger developed the first *safety match*. He placed the red phosphorus upon the surface to be rubbed and tipped the matches with a mixture of potassium chlorate and antimony sul-

fide. The type of match which today can be struck anywhere contains instead of phosphorus, phosphorus sulfide in the tip, and is comparatively harmless.

THE STORY OF A CANDLE

You all are familiar with a candle, but did you ever stop to philosophize upon the candle flame? The great chemist and physicist *Michael Faraday* once gave a course of six lectures on the *"Chemical History of a Candle"* before the Royal Institution of Great Britain. I have on the lecture table a lighted candle, the flame of which will illustrate and closely approximates most types of ordinary flames. The type of flame which it illustrates is one where we have a substance that we might call a fuel burning in air. Scientifically we would say that combustion of the fuel is taking place. Combustion is a type of chemical reaction during which sufficient energy in the form of heat is dissipated to be distinctly noticed, and further, in almost every case the reaction is visible, that is, there is some kind of a flame. The term combustion is also used in some cases where substances combine with oxygen, the reaction generally being very slow, hence the term *"slow combustion."* In these cases the heat generated may not be noticed because the action is so slow. Again we may have combustion, during which heat is generated and can be felt, but there will be no visible evidence (flame) of the reaction taking place. You will see therefore that the term combustion is very loose and not exactly specific.

If we examine the flame of the candle we will see that it consists of three portions concentrically superimposed upon each other like three inverted nested funnels. The inner portion is comparatively cold and consists of unburned volatilized fuel. The middle portion is the part that we see. It is a mixture of the fuel and air burning together and is hot. The temperature of the flame depends upon the nature of the fuel and the rate at which the air is supplied to the fuel. We can obtain the pattern of this hot middle section by pressing down on the flame a piece of cardboard saturated with alum. The alum prevents the cardboard from burning, and the pattern of the flame will be found to be a circle. The hot middle portion of the flame chars the cardboard before the rest of the flame. The outermost portion of the flame is a mixture of air and the products of the burned fuel from the middle portion. We can obtain the outline of this outer mantle by casting its shadow using a strong

light, either an electric lamp or an arc light. We can demonstrate to you that the innermost portion of the flame is unburned volatilized fuel by inserting in the inner cone a glass tube. Some of the gas will pass up the tube and a small flame may be obtained at the end of the tube. If we test the outermost portion of the flame for the products of combustion we will find that the two principal constituents are water, vapor and the gas, carbon dioxide. These two products will be found to be the two principal constituents of the gases or smoke from the burning of the common fuels, wood, coal and oil. These fuels or forms of them contain in addition to others the elements carbon and hydrogen; in the presence of the oxygen of the air they burn to form the combustion products. When the flame is restricted in its burning or the air supply is diminished considerably, the carbon is burned to a gas called carbon monoxide. This gas is poisonous to the body and when pure will give no warning of its presence in the air. A dangerous amount of carbon dioxide present in the air will give one the sensation of a smothered feeling.

Although practically all flames in the main consist of these three divisions, we can very often further subdivide parts of some flames. The inner cone may consist of varying degrees of atomization of the fuel, particularly if the fuel is oil and it is projected from a nozzle. If we examine the temperature of the middle part we will find that it varies. The hottest portion is found just above the tip of the inner cone. In order to completely burn the fuel or to obtain what we call complete combustion, some air can be mixed with the fuel before it is burned. The inner cone will then consist of unburned fuel and air. If I ignite a stream of ordinary illuminating gas I will obtain a rather large yellow flame that will billow and wave from the slightest air current. If I mix a small quantity of air with the gas before burning the flame will be reduced in size, practically uniform in shape and it may be almost invisible. In the first flame the fuel does not receive sufficient air to completely burn it. If we hold an object just above the flame it will become coated with a deposit of carbon. When sufficient air is present that carbon is burned to the gas carbon dioxide. In this flame some of the unburned carbon is caused to glow from the heat of the reaction, hence we see the flame. In the second flame all of the carbon was completely burned so that there was none to glow. It is not necessary however to have unburned glowing carbon to have a visible flame. One of the most common elements that we have, sodium, will give a yellow

flame. It exists in the form of sodium compounds very widely distributed over the earth's surface, and almost any substance that we burn will give us a sodium flame, because the color is so intense.

Compounds of a number of the elements that are capable of being volatilized in a flame will impart a color to the flame. Copper and barium compounds will give a green flame. Strontium, calcium and lithium give a red flame. The barium and strontium compounds are used to give the green and red colors in pyrotechnical displays.

When certain chemicals are mixed together and properly manipulated a number of unique flames may be obtained. By pouring some water on one mixture I can get an intense bluish-white flame and dense clouds of smoke. The mixture is simply zinc-dust, ammonium chloride and ammonium nitrate. A small amount of water poured on the mixture starts the reaction. Some of the zinc reacts with the ammonium chloride, heat is developed and the ammonium nitrate is decomposed, the zinc and ammonium nitrate then burn together. The excess ammonium chloride (sal ammoniac) is volatilized as a cloud of white smoke. Another method of producing fire with water is to take powdered magnesium metal (flash powder) and make a small cone. On one edge of the cone place some fresh sodium peroxide. A drop of water on the sodium peroxide will react with sufficient heat to ignite the magnesium.

THE LIME LIGHT

When magnesium powder or magnesium ribbon is ignited it will burn with a brilliant white light. The metal has a strong affinity for oxygen and may be easily burned. The heat of the reaction causes the magnesium oxide formed to glow and emit the strong white. The light from the hot magnesium oxide is very actinic, that is, it will act like daylight on a photographic plate. The flashlight that the photographer uses contains magnesium metal. Calcium is an element similar to magnesium in that its oxide when caused to glow will emit a strong white light. Intense heat is necessary and a hydrogen-oxygen flame is used in order to make the calcium oxide incandescent. Calcium oxide is best known to the layman as lime. These calcium lights or lime lights were formerly used when intense illumination was desired, particularly for lantern projection, etc. From its former use as a spotlight we get the expression *"to be in the lime-light."* Thorium and cerium oxides have a similar property, but do not require as high a temperature to become incandescent. A gas flame with the proper air mix-

ture will cause these oxides to glow, an example of which is the Welsbach gas mantle.

If I were to tell you that we could have a flame burning in water, it would excite your curiosity. I can show you one on the lecture table. In a tall glass cylinder place some crystals of potassium chlorate and carefully fill the jar with water. Drop into the water some small pieces of yellow phosphorus; they sink and rest on the potassium chlorate. Take a glass tube with a tip drawn on it (pipette), fill it with concentrated sulphuric acid by suction. Place the tube in the cylinder until the tip is just over the potassium chlorate at one side and allow the acid to flow over the bottom. Sharp, short flashes of flame appear in the water just over the pieces of phosphorus. With each flash there is heard a sharp click, like a water hammer.

Of further interest is the fact that we can have a flame burning in alcohol, an inflammable liquid. It is also easy to demonstrate. In a glass cylinder we place some alcohol and on the bottom of the cylinder some crystals of potassium permanganate. In the same manner as in the preceding experiment some concentrated sulphuric acid is introduced into the cylinder of alcohol just over the potassium permanganate. Flashes of flame will appear in the alcohol.

In the early part of the lecture I told you that *Plato* defined fire as "burning air." By a demonstration I can show that it may be literally true. Take a glass tube about two inches in diameter and about one foot in length. Arrange caps on both ends with a hole in them that can be closed by a sliding cover. Through one cap arrange a tube for the entrance of illuminating gas. Open the hole in the bottom cover and turn on the gas. When the tube is full of gas put a lighted taper near the open hole in the bottom. (The tube is clamped in a vertical position.) The gas issuing from the bottom hole will be ignited; reduce the gas flow until the flame is about two inches long. Now quickly open and close the hole in the top cap. The flame at the bottom will be drawn into the tube. Keep the hole in the top open until the flame is drawn into the tube, then close the hole. If it is not drawn into the tube, reduce the size of the gas flame and try again. When the flame is *outside* of the tube it is a *gas flame burning in air;* when the flame is *inside* of the tube it is an *air flame burning in gas.* If the flame when burning in the tube is reduced to an inch in height and the hole slowly opened in the top, the flame will move up the tube and dance in a spritely manner in the middle.

If we reduce the temperature of the middle section of a flame below the ignition point of the fuel the flame will be extinguished at that point. If I press a piece of wire gauze down on the flame I apparently push the flame into the gas tube. Actually the temperature above the gauze is below the ignition point of the fuel. As soon as the gauze becomes hot the flame will be on both sides of the fuel.

THE SONG OF THE FLAME

By properly manipulating a flame, particularly a jet of gas flame, it can be made to "sing." The phenomenon is similar to that of the sound production in an organ pipe. It depends largely upon the aperture from which the gas issues. A very quiet burning gas flame may often be sensitive to musical notes. The silhouette of the flame will be changed by the air waves of sound according to the pitch of the note or notes. We can cause glass tubes or iron pipes to give their fundamental note by using a flame. A piece of iron gauze is placed a short distance up the tube; the correct place must be determined by trial. A suitable flame is passed up the tube and allowed to strike the gauze. The most convenient way is to hold the tube over a bunsen burner. The flame playing on the gauze causes the air in the tube to become heated and to vibrate. Then the fundamental note of the tube is heard and generally some harmonics of that note. In some tubes the vibration of the air is sufficient to extinguish the flame.

An interesting liquid used to obtain a luminous flame for lighting purposes some years ago was a mixture called *camphene*. It was a mixture of turpentine and alcohol. Alcohol will burn with practically a non-luminous flame. Turpentine burns with a luminous flame and deposits quantities of soot. There is more carbon present than can be completely burned. The mixture of alcohol and turpentine will give a luminous flame with practically no deposit of soot.

FLAMMEN-WERFER

One of the most frightful uses of flame was during the World War. In July, 1915, the Germans introduced the *Flammenwerfer* or flame projector. It was a device for projecting a liquid under pressure that would readily burn. The psychological effect of these flame projectors was greater than the actual physical one.

So far, we have been principally concerned with flames in which air had a part. If we take the active constituent of the air, oxygen, and burn our fuel with the oxygen, the reaction becomes in some cases

very violent. The temperature of the flame will considerably increase. A gas-oxygen flame is used by jewelers for the hard soldering of jewelry. If we substitute for illuminating gas another gas, acetylene, the temperature will be still higher. An oxy-acetylene torch will produce a flame that will melt iron. An oxy-hydrogen flame is still hotter and will melt platinum. If the time were available we could dwell considerably upon these two flames.

THE HOTTEST FLAME

There has been recently developed another flame that we may safely say is *"the hottest flame on earth."* It is called an *atomic hydrogen flame*. Hydrogen gas as we know it exists in a molecular condition. Each molecule of the gas contains two atoms. When a jet of hydrogen gas is blown through an electric arc the hydrogen molecule is split apart into the two atoms, but these two atoms combine again to a molecule of hydrogen which further burns to form water. The temperature of the electric arc itself is very high, but when the molecule of hydrogen is broken up and the atoms recombine, an immense amount of energy is liberated in the form of heat. The flame has been estimated to have a temperature of 10,000 degrees Fahrenheit. This flame was developed from a theoretical investigation of electric lamp filaments by Dr. Irving Langmuir of the General Electric Company. Two of the most refractory of metals, tungsten and molybdenum, are easily melted by this flame. Welds made with this flame are not contaminated with carbon, oxygen or nitrogen. Alloys containing metals easily oxidizable can be welded without the use of fluxes and without oxidation.

Any discussion of flame would be incomplete without some mention of the flames of the sun. No one can adequately visualize the size of the flames on the surface of the sun. The energy represented by the sun's flames is beyond all comprehension. Physicists tell us that the constitutional energy of a breath of air is 1500 horse-power years, and would operate a powerful aeroplane for two years continuously. How can we comprehend then that the sun's flames are radiating 4,660,000 tons of energy every second. At noon on a perfectly clear day in June the sunlight falling on the 133 square miles of Philadelphia is equivalent in power to one hundred Niagaras.

ANIMALS THAT LIVE IN MAN

By Marin S. Dunn, Ph. D.

"Great fleas have little fleas,
Upon their backs to bite 'em,
And little fleas have lesser fleas
And so ad infinitum."

A PARASITE IS A PLANT or animal which spends all or part of its life in or upon other plants and animals (hosts). It is more or less dependent upon its host for food and instead of returning good for good produces various disease conditions. Sometimes the offender lives upon the skin of its victim, and in other cases it may be found lodged deep in the alimentary canal, lungs or in the very muscles. Parasites exhibit varying degrees of complexity in the history of their lives and the conditions under which they find themselves. In fact, some parasites require more than one host to complete their cycle. Thus the tape worm, Taenia saginata, is found at one time in the muscles of the ox and at another time in the intestinal canal of man.

Marin S. Dunn, Ph. D.

The degree of dependency of a parasite upon its host varies in the different species and we may trace a series from forms which are parasitic only for a short time and are found on the outside of the host to those forms which are highly modified and completely dependent upon the individuals in which they dwell. There are distinct effects upon the parasite produced by the manner of life it is living. As a parasite becomes more and more dependent upon its host for its food, its own digestive tract may become increasingly simple and finally disappear. Hooks and suckers are developed which permit the owner to cling to the walls of the host (see Fig. 3), and since the parasite is no longer compelled to move from place to place seeking food, its nervous system, sense organs and organs of locomotion undergo modification. Finally, the number of eggs produced is enormous. In fact, each segment of an adult tapeworm is merely an egg-producing machine. (See Fig. 4.)

On the other hand, parasitism is not without its effect on the host. (1) Poisons known as toxins may in some cases be liberated

by the parasite. It is thought that this is the reason for the rise in temperature during malarial fever. (2) The channels of the body fluids such as the lymph and certain ducts may be clogged by the parasite. (3) Blood-sucking forms may deprive the host of too much blood. (4) Local to widespread inflammations and sores may be produced—hence the ulceration of the intestines in amebic dysentery or the widespread lesions of congenital sylphilis.

Parasites have been found in almost every portion of the body of man—in the intestines, the liver, the lungs, etc., and man has suffered through the ages as a result of their existence. At first, he thought his sufferings due to supernatural causes, the wrath of heaven and evil spirits, but this belief did not prevent him from trying to produce cures by using plants known to have or tried for medicinal virtue. Let me quote a few passages from Human Parasitology by Damaso Rivas.[7]

ANCIENT KNOWLEDGE OF PARASITES

"The Aryan race possesses the Ayurveda, a medical book that is believed to have originated directly with Brahma; it was later corrected by Charaka, whose name it bears. This race also possesses another book by Susruta, in which fevers are attributed to the bites of mosquitos."

"It is probable that the Egyptians had some knowledge of the presence of hookworm in the intestine."

"In the Book of Numbers a disease is described caused by fiery serpents, which probably refers to guinea-worm (Dracunculus or Filaria medinensis), and it appears that Moses taught the Jews how to extract the worm by means of winding it around a stick."

"Hippocrates (460 B. C.) distinguished intermittent from continuous fever, differentiated the three types of malarial fever (tertian, quartan and subtertian), noted their occurrence during summer and autumn and the prevalence of the disease in swampy localities and after rain."

And so through the ages, man has been gradually adding to his knowledge of the organisms that beset him. A few examples will suffice. In 1839, Dubini discovered the hookworm (Ankylostoma duodenale). It remained for Laveran in 1880 to discover the malarial parasite and in 1901, Ford found a minute organism in human blood which Dutton later called the Trypanosoma gambiensis—the cause of African sleeping sickness.

It is the purpose of this paper to select a few of the more important animal parasites which affect the peace and happiness of

man and to tell a little concerning their structure, their life history and finally to mention, in certain cases, the protective measures which man has used in his warfare against them. It must be emphatically stated that anyone suffering from any disease should place himself in the hands of the most competent physician that he is able to find and endeavor to follow directions intelligently.

For the purpose of classification, the animal parasites of man mentioned in this paper may be grouped into three large classes—the Protozoa, the flat worms and the round worms.

PROTOZOA All plants and animals are composed of minute units of living matter called protoplasm. These units are termed cells and their size and number depend upon the organism with which we are dealing. Protozoa are tiny bits of animal life whose body consists of a single cell and that cell (often so small that the higher powers of a miscroscope must be used to see it clearly) carries on the same vital activities that we find in the more complex many-celled animals.

Let us suppose that we are looking at an Ameba proteus, (see Fig. 1) a fresh water form, $\frac{1}{100}$ inch in diameter, under our microscope and that we are studying it as a representative of the Protozoa. Its body is more or less colorless and is composed for the most part of granular protoplasm except around the edge where there is a firm clear layer. If we are fortunate, we may discover a clear space filled with fluid which now and again contracts (contractile vacuole) and forces the contents out of the body. This is probably a primitive excretory organ. Food particles such as Bacteria are engulfed at any point on the surface of the body and food vacuoles which consist of the food covered by water are thus formed. Digestion takes place and the undigested remains pass out of the body as the Ameba oozes away. All living plants and animals must breathe and in the case of Ameba, oxygen dissolved in the water is taken in through the surface of the body and carbon dioxide probably passes out of the body by means of the contractile vacuole and also through the general surface of the body. Reproduction is accomplished by the animal dividing into two parts.

One of the characteristics that we associate with animals is the power of locomotion. They are able to move from place to place, and on this basis, we may divide Protozoa into three classes. The first class (Sarcodina) is that to which the Ameba belongs and its

members move by extending from their cells finger like protrusions known as false feet or pseudopodia. The rest of the protoplasm of the animal flows or oozes into the "pushed-out" part and therefore motion is in the direction of the extended portion. (See Fig. 1.)

The members of the second class (Mastigophora) are provided with whip or lash-like extensions of the body (see Fig. 2) known as flagella. In case of the third class (Infusoria), the body is more or less covered by little hairs known as cilia. These act like small

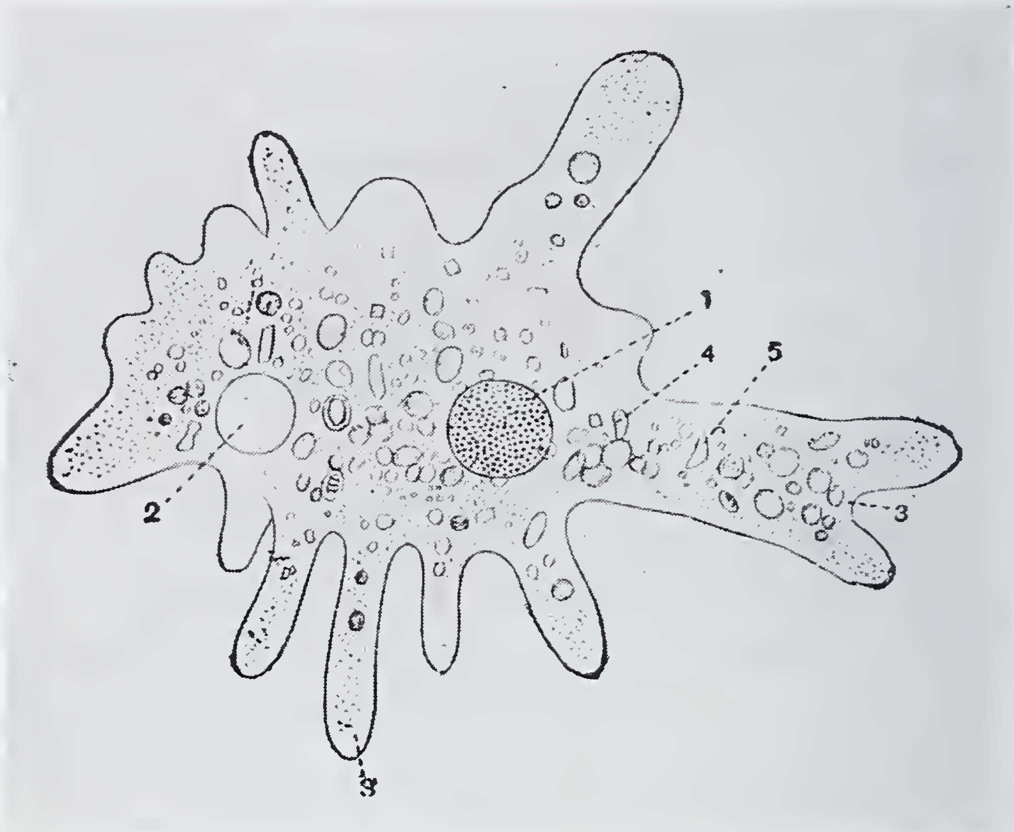


FIG. 1

Ameba proteus. 1, nucleus; 2, contractile vacuole; 3, pseudopodia; 4, food vacuoles; 5, grains of sand. (From Hegner.)

oars when they are vibrate and consequently the animal is able to move backward or forward.

In addition to the three classes above mentioned, there is still another class (Sporozoa) of Protozoa whose members are without motion in the adult state.

SARCODINA There are certain Ameba-like organisms which are found in Man—occurring in the mouth, the large intestines and now and then in the liver and the lungs. These forms are given the name Endameba and they have no contractile vacuole. Some of them are harmless while others cause pronounced disturbances.

Endameba gingivalis is a common parasite of the mouth and it has been regarded as the cause of pyorrhœa. The problem is a complicated one since we must remember that a number of other organisms are present in cases of pyorrhœa and that the amebas may be the result rather than the cause of the infection.

Beatrice F. Howitt [3] has published a paper upon the effect of certain drugs and dyes upon the growth of Endameba gingivalis in vitro and she has found that of the arsenicals she tried, Stovarsol was most effective in killing the organism and acetylarsan the least so. Likewise, arsenical compounds were more effective than the non-arsenicals she investigated such as yatren.

Endameba coli is commonly found in the large intestine of man and feeds upon the materials found in the bowel. It is probably non-pathogenic.

Endameba histolytica and E. tetragena, two other forms are also found in the lower bowel of man and they have been found to cause dysentery. In fact E. histolytica has been known to escape from the intestines under certain conditions and to appear in abscesses of the liver, lung and brain.

MASTIGOPHORA We now come to those forms of Protozoa moving by means of flagella and we will use the Trypanosoma (see Fig. 2) as our example just as we used the Ameba as our representative for those forms moving by means of pseudopodia. In the blood of vertebrates such as man, cattle, fish, frog, bird, etc., they are found and are charactertized by their undulating membrane and long whip-like flagellum (see Fig. 2). In 1902, two workers, Forde and Dutton by name, discovered that Trypanosoma gambiense was the cause of "sleeping sickness" in man, and later about 1910, Stephens and Fantham found T. rhodesiense to be the cause of a sleeping sickness in man in the regions of Northeast Rhodesia in Africa.

Trypanosoma gambiense measures in length $^{18}/_{1000}$ to $^{30}/_{1000}$ of a millimeter or $^{18}/_{25000}$ to $^{30}/_{25000}$ of an inch, and is found in the blood, lymph glands (lymph is a colorless fluid found in animal bodies and is contained in certain vessels known as lymphatics) and spinal fluid of those afflicted with sleeping sickness. It is carried from one person to another by the tsetse-fly and introduced into the new victim through the bite of the fly. The Trypanosoma passes through

certain stages in its life cycle in the fly and eventually reaches the salivary gland and proboscis. As it takes some time for this part of the Trypanosoma's cycle, the tsetse-fly does not become infective until about eighteen days after feeding on parasitized blood and it is capable of remaining infective for about three months. Characteristics of trypanosomiasis are irregular fever in the beginning, general debility and progressive physical and mental lethargy.

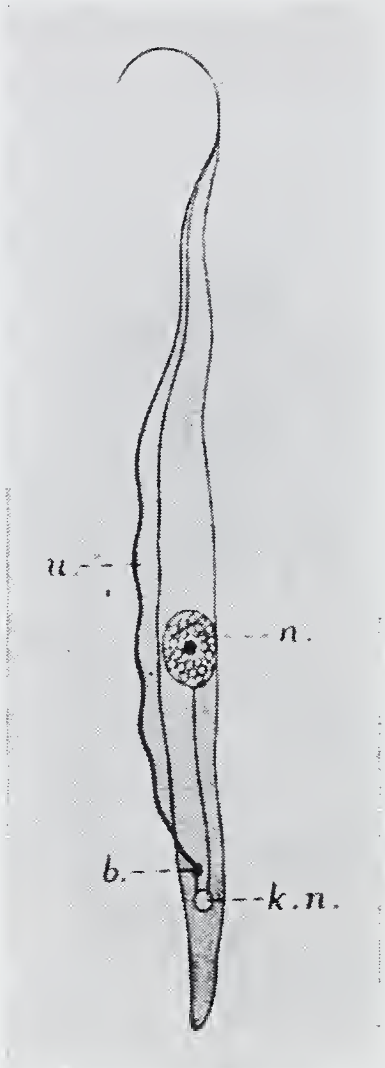


FIG. 2

Trypanosoma, showing n, the nucleus; u, the undulating membrane and the flagellum. (From Parker & Haswell.)

T. rhodesiense is found to cause sleeping sickness in Rhodesia and is transmitted to man by the bite of a fly—the Glossina morsitans. The disease produced is similar to that of T. gambiense.

T. cruzi is the name of the parasite discovered in the intestines of a bug at the Institute Oswaldo Cruz, Rio Janeiro by Chagas. Investigations by Chagas proved this flagellate to cause a number of acute and chronic diseases particularly among children, now termed Chagas disease or Trypanosomiasis Americana. The mortality is high.

INFUSORIA These protozoans are not usually prevalent as parasites of man. Balantidium coli, an oval ciliated form, is a parasite of the large intestine in man, hog, orang-utan, etc. It is carried to the digestive tract of man from the rectum of the pig either through eating uncooked, contaminated food or through contaminated water. The organism produces a distinct kind of dysentery.

SPOROZOA The story of malaria has been intimately bound with the history of the human race and has been associated in the mind for ages with marshy ground. In fact, the name of the disease is derived through the Italian from two Latin words malus and aer meaning "bad air." [4] The disease takes the form of a fever and is characterized by certain peculiarities. These begin with headache and chilly feelings which are followed by a severe chill. Next, there is a rise in the temperature of the patient, and the skin is hot and dry. After an interval, there comes perspiration, the fever disappears and the patient may sink into sleep.

In 1880, a French army surgeon, Charles Louis Alphonse Laveran discovered the "germ" which causes malaria. For a number of years afterward, however, it was not known how the parasites entered the human body. Finding that the parasites did not appear to leave the body in any of its waste materials, Sir Patrick Manson came to the conclusion that they must be taken up by some sucking insect such as the mosquito which was found to abound in infested localities. Major Ronald Ross continued this line of thought and his painstaking work showed the mosquito to be the intermediate host of the parasites. Thus it was found that malarial fever was not brought about by swampy conditions except inasmuch as swampy regions act as fertile breeding grounds for mosquitoes.

The developmental cycle of the "germ" occurs partly in man and partly in certain mosquitoes. If we examine, for example, the blood of a person who is suffering from malaria, we may find a pale organism inside of the red blood corpuscles. These forms found in the corpuscles of the victim grow and divide into many little bodies called spores which are finally liberated into the blood stream through the disintegration of the corpuscles. If the spores are not absorbed by the white blood corpuscles, they enter new red blood corpuscles and the cycle is repeated. After a time, sexual forms (gametes) develop in the red blood corpuscles, and these are conveyed to stom-

ach of certain species of mosquitoes, which have bitten the malarial patient. In the mosquito, the malarial organism passes through a complex history and finally certain spindle-shaped forms are carried in the blood stream of the mosquito to the salivary glands, and then are conveyed through the bite of the mosquito to the next human victim. The rôle of the mosquito as intermediate host of the parasite was found out by Ross and Manson. "Thus, Anopheles mosquitoes were fed on the blood of malarial subjects in Rome and then sent to London, where a son of Dr. Manson allowed himself to be bitten by the insects. Though previously free from the malarial organism, he contracted a well-marked infection as a result of the inoculation." [1]

Anopheline mosquitoes may be distinguished from most of the other United States mosquitoes by having (1) their wings more or less spotted; (2) in resting their bodies inclined away from the surface at an angle while the bodies of the other types are parallel to the surface; (3) the length of certain mouth parts in the female.

The following are three well-known types of malaria: (1) Tertian fever caused by the sporozoan, Plasmodium vivax, in which the attack recurs every two days; (2) Quartan fever caused by P. malariæ with the paroxysm every third day, and (3) Estivo-autumnal fever caused by P. falciparum with daily or irregular attacks.

It has been found that the symptoms manifested by the parasitized person correspond to certain stages in the life cycle of the malarial parasite in the body. When the spores are formed and liberated into the blood stream, there is the chill, and the fever which follows marks the entrance of the spores into new red blood corpuscles. The crisis and afebrile period occur while the growth is taking place within the new corpuscle. Quinin which may be classed as a specific should be taken at the crisis stage at the time the young form is beginning to grow in the new blood corpuscle and the temperature of the patient beginning to fall because the parasite is more easily destroyed since it is young and beginning to feed rapidly. Quinin is not effective in killing the sexual forms or gametes which pass part of their life in the body of the mosquito. One dose of quinin may be only sufficient to protect against a subsequent attack but may not give permanent cure against those attacks which will occur after weeks. To prevent these recurring attacks, the treatment must be more protracted and should be carried out by the patient under the care of a competent physician.

In communities located in malarious localities, as high as 25 per cent. of the mosquitoes sometimes have been found to be infected. These bite the babies and children who as a result develop as they grow up characteristic anemic conditions and possess enlarged spleens. The treatment of long-standing cases is unsatisfactory and tonics of iron and arsenic have been recommended.

Beside the treatment by quinin of those persons suffering from the disease, all persons in a malarious community should be required to have blood examinations. Precautions should be taken to destroy the larvæ of mosquitoes in their breeding places, such as stagnant ponds, pools, swamps, etc., and about 1 cc. of petroleum should

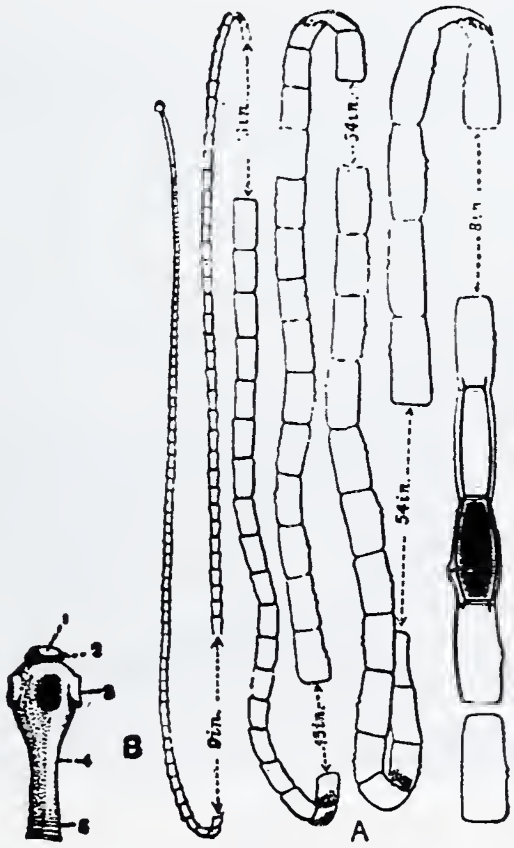


FIG. 3

Taenia saginata. A, The segments of the adult worm showing appearance. The approximate lengths of the portions omitted in the drawing are given. B, The head showing 2, hooks; 3, suckers; 4, neck. (Fig. taken from Hegner.)

be applied to the square meter of water at least once per week. Drainage of these breeding places should be undertaken wherever feasible. Avoidance of mosquito bites by properly screened rooms and beds, the application of washes of eucalyptus oil, camphor oil, etc., and the separation of malarial patients from the rest of the community are worthy preventive measures. Koch has advocated as a preventive measure the "taking of from 10 to 15 grains of quinin, previously dissolved in water acidulated with hydrochloric acid, once or twice a week during the summer months." [7]

We now come to certain many-celled parasites of man, namely the various worms. For our purpose, we may divide the worms into two groups—the flat worms and the unsegmented round worms.

FLAT WORMS Some flat worms are found free living in fresh or salt water and on land while others like the tapeworm lead a parasitic life. Let us use the common tapeworm Taenia solium (Fig. 3) as our specimen to show the characteristics of the group. The adult animal lives in the digestive tract of man and clings to the wall by means of the hooks and suckers which are found

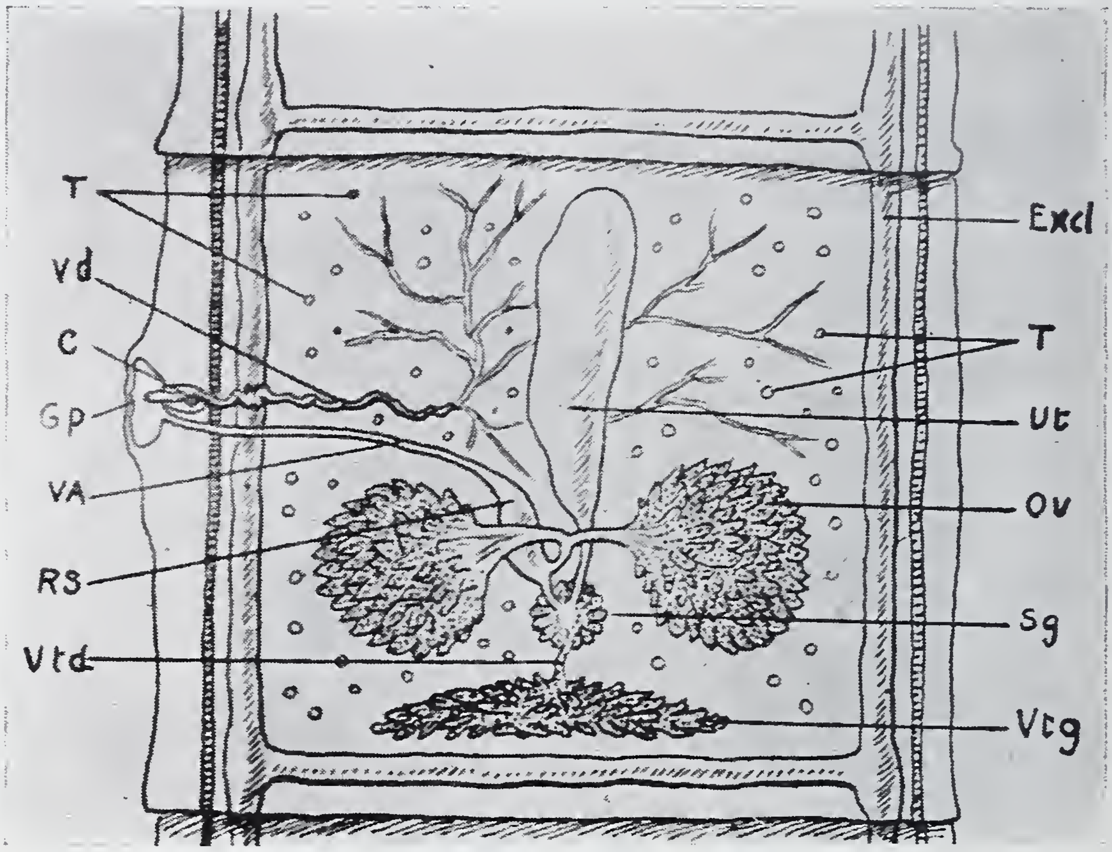


FIG. 4

Taenia saginata. Anatomy of a maturing segment, showing among other things T, testes; Ov, ovaries; Ut, uterus; Sg, shell gland; Gp, genital pore; Exd, excretory duct. (Fig. from Rivas.)

on its knob-like head. In back of its head is a short neck from which there are budded off the series of segments which make up the rest of the animal's body. The further from the neck a segment is, the larger it becomes and the more mature. In fact the entire worm may possess as many as eight or nine hundred of these segments.

As we might suspect, Taenia possesses no alimentary canal but because it is living in a region of the host rich in digested foods, it is able to absorb these through its own body wall. There is a simple nervous system, and the excretory tubes which are found on both sides of the animal open at the rear end of the body and pass out

the waste. The reproductive organs are highly developed—each segment contains both male and female organs. In fact, the mature segments which later break off and pass out of the host's body with the waste of the host are almost completely filled with the reproductive parts. (See Fig. 4.)

If the eggs (which already have started to develop into hooked embryos while in the segment) or segments are swallowed by a hog, further development may take place. The embryos may escape in the intestines of the hog, penetrate through the intestinal membrane and reach the blood stream by which they are carried to the muscles and internal organs. Once there, they form what are known as bladder-worms. The bladder-worms possess a little head provided with hooks and suckers. Pork infested by these larvæ is known as "measly pork" and if eaten by man, unless it has been sufficiently cooked, may cause the eater thereof to become parasitized by Taenia. Once in the human intestine, the head of the bladder-worm becomes fastened to the wall and a new series of segments begin to develop.

Another common species is Taenia saginata (see Fig. 3), the beef tapeworm, which lives as an adult in the intestines of man and spends its bladder-worm stage in cattle. The length of the adult varies from 4 to 10 feet and many contain upwards of 1000 segments. It is said that unlike T. solium, "the segments of T. saginata force their way through the rectum by their own activities, and as this may occur at any time, and more especially during the night, in suspected cases the attention of the patient should be directed to this possible occurrence."

The adult worm in man causes various alimentary disturbances —often alternating diarrhea and constipation. It is difficult to eliminate because its head hangs tenaciously to the intestinal wall and even though the segments be removed by passage through the alimentary canal, nevertheless, new segments may be continually budded from the head region. Male-fern in suitable form and of suitable dosage followed by a saline purgative is used in treatment and in some cases, Pomegranate and thymol have given results. Properly inspected meat and thorough cooking are wise preventive measures.

Nor is man confined alone to the adult stage of the parasite. There are certain tapeworms whose bladder-worm stage is spent in man and which spend their adult life in other animals. For example, the Echinococcus granulosus, a small club-shaped animal with only three or four segments, passes its adult life in the small in-

testines of the dog and the wolf, but its bladder-worm stage occurs in certain organs (liver, lung) of man, and give rise to peculiar tumors.

UNSEGMENTED ROUND WORMS

The members of this group, in contrast to the forms we have just been reviewing, have cylindrical bodies, at one end of which is a mouth and near the opposite end an anal opening. Their plan of structure is really that of a tube within a tube—the outer tube being the body wall and the inner, the digestive tract. The sexes are separate—that is some worms possess male organs and others female. Round worms are both free living and parasite. It is our purpose to pick out certain forms parasitic in man and through a discussion of their structure and life histories to show something of the characteristics of the group.

Ascaris lumbricoides, whitish-yellow in color, is said to be the largest round worm parasite of the intestines. The female measures about eight to fourteen inches in length and the male is about one-half as long. In children, it is a frequent parasite. The eggs are laid by the adult worm in the human intestine and they pass out through the anus with the undigested food. Each egg is oval and is surrounded by a thick shell and may remain alive for long periods of time. "Morris noted that in human feces which had been kept two years in 2 per cent. formalin some of the eggs of A. Lumbricoides present contained active embryos." [6] It is evident that they have the power to remain alive even though lying upon the ground for long periods of time. If proper conditions are met (such as moisture and temperature), an embryo develops and if chance is kind, this may find its way again into the intestine of man or some other suitable host where the larva may be set free and attain its adult state in about five or six weeks. Stewart has suggested that mice and rats may play the part of intermediate host in the cycle of Ascaris lumbricoides but the researches of B. H. Ransom and W. D. Foster [6] seem to indicate that "no intermediate host is necessary, and human beings and pigs become infected with Ascaris as a result of swallowing the eggs of the parasite, and not as a result of swallowing food, water or other substances that have been contaminated by the feces of rats or mice."

In marked cases of Ascaris parasitism, there is gastro-intestinal disturbance often combined with nervous symptoms such as night-

mare, mental and physical debility, convulsions, etc. Santonin taken in castor oil is almost specific. It has been found to be more effective taken on an empty stomach in the morning.

Oxyuris vermicularis. This is the small parasite known as the "pin" or "seat" worm (see Fig. 5). It lives in the intestines of man, discharges its eggs into the intestine and the adult worm has a tendency to pass through the anus to the exterior of the body. Infestation of the appendix may give rise to appendicitis. Other symp-

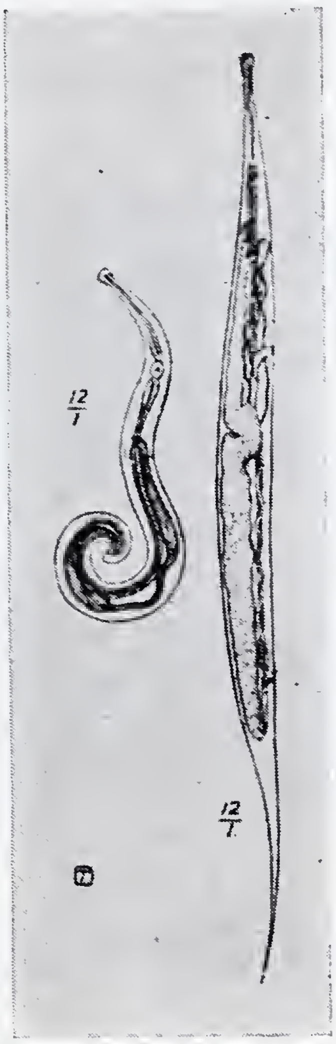


FIG. 5

Oxyuris vermicularis, the "pin" or "seat" worm. The male is to the left and the female to the right. (Taken from Rivas.)

toms are nervousness, vertigo, convulsions, etc. Objects contaminated with the eggs of the worm may lead to reinfection if placed in the mouth. Rectal injections of tannic acid, 1 per cent. infusion of santonin, soapsuds, etc., will remove the adult worms from the rectum and anus. For the removal of the younger forms living higher up in the small intestines, it is necessary to resort to the use of thymol or santonin. The patient must be kept clean to avoid autoinfection.

Ankylostoma duodenale, the European hookworm, has been found to be very harmful to man. Nausea, vomiting, diarrhea alternating with constipation, fever, physical and mental lethargy, emaciation, anemia and death are some of its results. The worm is cylindrical, with reddish tinge and the ends have a tendency to be pointed. The mouth cavity is armed by means of hooks which serve to attach the parasite to the intestines of the host. (See Fig. 6.) Added to this equipment are a pair of glands which secrete a substance which prevents the coagulation of the blood of the host. The worm in the adult state lives in the small intestine of man and anthropoid apes. Let us briefly follow its life history. The eggs pass

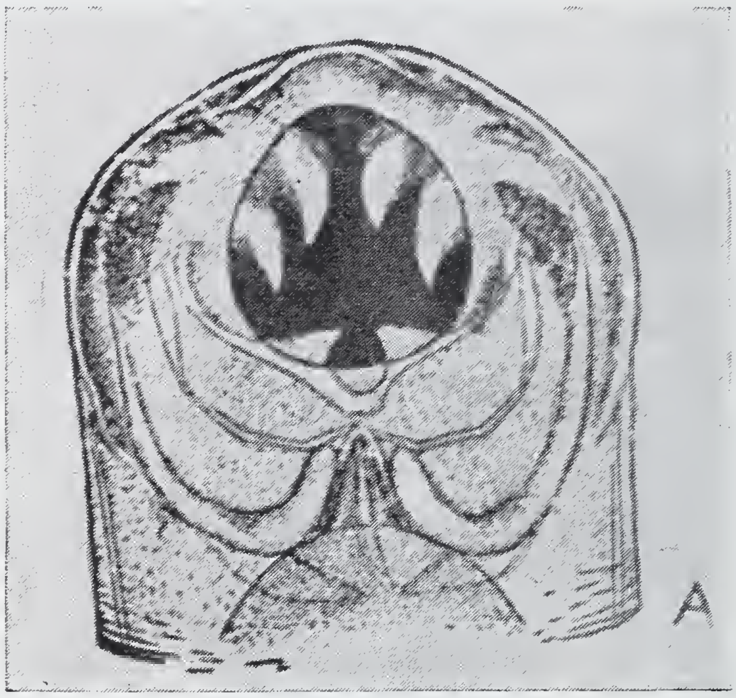


FIG. 6

Ankylostomum. Mouth and mouth cavity of old world hookworm, showing teeth or hooks. (Taken from Rivas.)

out of the intestines of the host with the feces which are often deposited upon the ground. A needle-shaped larva soon escapes from the eggs and begins to rapidly grow. As it grows, it changes and in a short time, it ceases to feed and rests for a month. At the end of this time, if chance permits, it may infect the human who is so unlucky as to touch it with his bare skin by entering the hair-follicles —or the larva may be swallowed with the food.

Once inside the human body, the larva finds its way to the heart and lungs. From there it passes up the bronchial tubes, the windpipe and finally enters the digestive system. It passes through the esophagus and is carried with the food stream into the stomach and the intestine where it reaches maturity. The eggs make their ap-

pearance in the undigested food of the host at about the seventh or eighth week after the larva first enters the body.

In treatment of the patient, thymol and betanaphthol have proved useful. Thymol may be given in the form of an odorless and tasteless preparation known as thymotal followed by a purgative. Essence of eucalyptus has been given with success.

Stringent prophylatic measures should be adopted in localities where the disease is known to exist. Thorough inspection of the feces for eggs should be made for everyone and those individuals who are found to be parasitized should be segregated and treated until examinations over a period of time prove them fit to associate with the rest of the community. A five per cent. solution of lysol, chlorid of lime, etc., should be sprinkled upon the ground to prevent the development of larvæ, and excrement should be burned or buried deeply. Enforcement of personal cleanliness must be insisted upon and the public educated up to a point where they will work hand in hand with competent doctors to stamp out the hookworm pest.

Necator americanus is another hookworm which was named by Stiles in 1902. While there is some difference in the anatomy of Ankylostoma and Necator, yet the habitat, life history, manner of transmission, etc., is practically the same and was discussed under Ankylostoma.

The shiftlessness of the "poor whites" in the rural districts of our own Southern states is due at least in part to the effects of hookworm parasitism. The people are poor and have no knowledge of sanitation. Their excrement is deposited upon the ground, and later on, the larvæ of the hookworm find their way through the uncovered feet of the human victims. Once inside, they pass through their natural cycle rendering the victim anemic and subject to tuberculosis owing to injury done by them to the lungs.

Trichuris trichiuras, from its resemblance to a whip or lash is known as the "whipworm," and it is found in the cecum and appendix of man. When food or water containing the embryos of this worm are taken into the body, the embryo passes to the intestine. There it takes about a month to mature. The eggs are passed out of the body with the feces and take almost a year to mature. The worm is a common intestinal parasite and it may not make its presence felt. In some cases, it may occasion appendicitis.

Trichinella spiralis, a small whitish parasitic round worm of the intestine is just about visible to the naked eye. Completely-

formed free embryos are produced by the worm which finally reach the blood stream from the intestine. Later, these become encysted in the muscles, (see Fig. 7) such as tongue, abdomen, etc. Each cyst under magnification shows a coiled up organism surrounded by a membrane. In this condition the worm may stay alive for years. Infested hog meat, improperly cooked, and containing encysted forms may be eaten by man, who, himself, as a result may become parasitized.

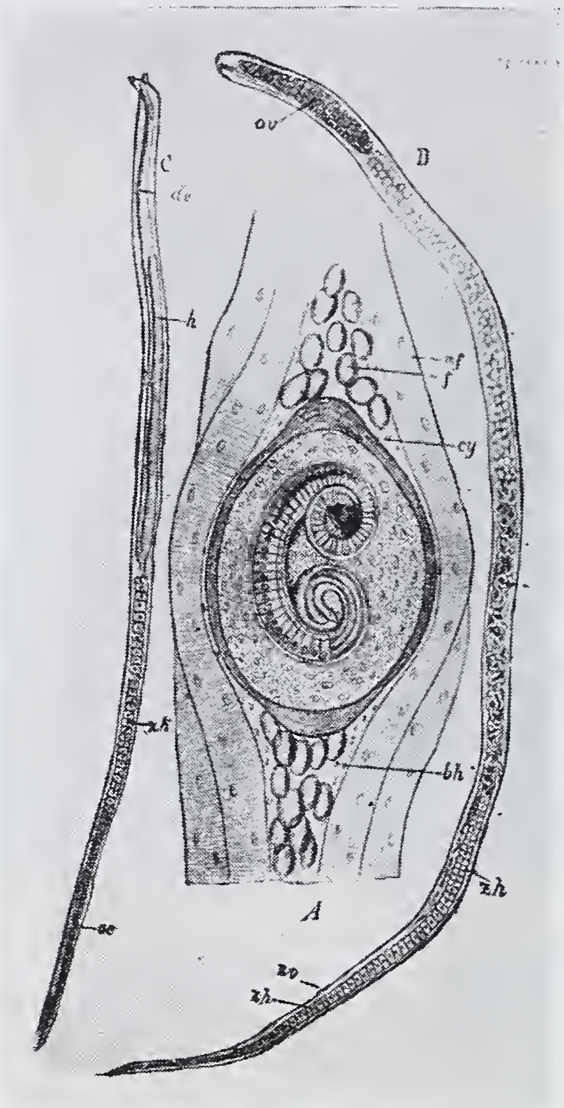


FIG. 7

Trichinella spiralis. A, encysted form in muscle of host; B, female; C, male; h, testes; ov, ovary. (From Parker & Haswell.)

Since man has done much experimental work on the life history of Trichinella in the rat, let us trace what happens when a rat eats meat infested with Trichinella cysts. The embryos grow rapidly in the small intestine of the rat and in three or four days they become sexually mature. Later, the embryos are discharged by the adult Trichinella into the lymphatic capillaries. They (embryos) are carried by the blood stream over the entire body of the rat and finally lodge in the fibers of the voluntary muscles and there become encysted.

The encysted embryos may retain their vitality for a long time and may be a constant source of danger. B. H. Ransom, B. Schwartz and H. B. Raffensberger [5] have investigated the "Effects of Pork-Curing Processes on Trichinæ." Some of their conclusions are as follows:

"Pork products of kinds customarily eaten without cooking may be rendered safe for consumption, so far as the dangers of trichinosis are concerned, by certain curing processes. No single formula can be applied to all such products, as different ones require different treatments, depending largely on their size and on whether they are smoked."

"Sausage smoked for six hours at a temperature of about 100 degrees F. followed by 10 days of drying are not rendered innocuous. This procedure is accordingly not recognized by the bureau as meeting requirements for the destruction of Trichinæ in sausage."

"Hams are rendered innocuous by the following methods: (1) The products are cured by means of dry salt (4 pounds of salt per hundredweight of meat) for at least 40 days at a temperature not lower than 36 degrees F., and then smoked or pale-dried for 10 days at a temperature not lower than 95 degrees F.; or (2) the products are cured on the basis of three days' cure for each pound of weight of individual hams, followed by forty-eight hours of smoking at a temperature not lower than 80 degrees F. and finally by twenty days' drying at a temperature not lower than 45 degrees F."

The disease produced by Trichinella in man is known as trichiniasis and it presents various stages such as (1) catarrhal inflammation of the intestinal tract, vomiting, nausea, etc.; (2) fever and muscular pains; (3) general mental and physical debility; (4) severe gastro-intestinal trouble, blood-poisoning, etc.

Treatment is given at first by means of emetics and purgatives. Thymol followed by a purgative may be used to expel the adult worms. Once the embryos are encysted, they cannot be detached. The rat is the natural host of Trichinella and all rats should be eliminated from the vicinity of pig pens and houses. Inspection of the meat by those who are qualified to do so and the thorough cooking of it in the home are two necessary prophylactic measures.

Filaria bancrofti is a whitish round worm parasitic in man. The embryo developing from the egg reaches the blood stream and the heart. Under high magnification, it is seen to be enclosed in a sheath. At night these forms are found in the blood-vessels of the skin of

the victim but during the day they live in the deeper parts—the larger arteries. No further development takes place in the human but certain mosquitoes act as intermediate hosts.

The embryo entering the stomach of the mosquito in the blood obtained from a parasitized person which it has bitten, breaks out of the sheath and passes through the stomach walls and comes to lodge in the thorax muscle. Here it undergoes development into the larval stage and then passes to the mouth parts of the mosquito from where, later on, it passes to a new human during the operation of the mosquito bite. On entering the human body, the larvæ are carried by the lymph channels or the blood to the pelvis and abdo-

FIG. 8
Elephantiasis of the legs. (Taken from Rivas.)

men where they grow into the adult stage. Eggs are produced by the adults and the life cycle is complete.

Probably because the channels are obstructed by the parasite the lymph is stagnated and as a result, the legs (see Fig. 8) and certain other parts of the body may swell to great sizes. This disease is characteristically tropical, and it is said that many natives of certain South Sea Islands are so afflicted.

In localities where the disease is prevalent, the beds should be covered by mosquito netting and the houses should be screened properly. Just as in the case of malaria, the breeding places of mosquitoes should be treated and the mosquitoes thus destroyed.

Thus we see that there are other organisms in this world, beside the Bacteria, which may live in and prey upon man, and that, in certain cases, the diseases they cause may be severe enough to produce lasting sickness or death itself. The world owes a debt of gratitude that it never can repay to those heroes who are risking their lives in infected zones in order that the facts concerning some pest may become known and its elimination take place. People, also, must come to a fuller realization of the need for personal cleanliness such as frequent bathing and changing the clothes, and those who suspect parasitic infection should consult the most competent physician they know and intelligently follow his directions. The breeding places of mosquitoes, flies and other insect carriers must be wiped out, and the common mouse and rat must go from our homes. There is yet much to be done in this fascinating field by field and laboratory workers alike, and the scientist is spurred on in his quest for truth by the knowledge that new information may accomplish lasting good.

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